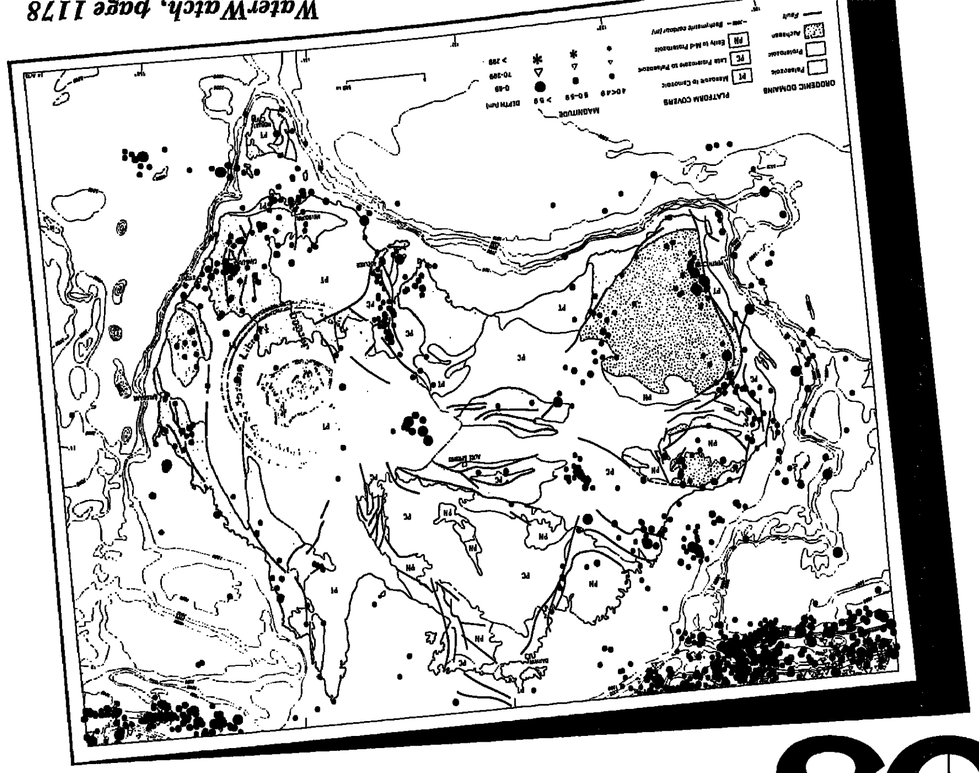

EOS

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Geomagnetism and Paleomagnetism

2530 Spatial Variations
VISCOUS REMANENT MAGNETIZATION MODEL FOR THE BROKEN RIDGE SATELLITE MAGNETIC ANOMALY
R. David Johnson (Centre for Geophysical Exploration Research, Macquarie University, North Ryde NSW 2113, Australia).

A range of crustal models for the interpretation of the Broken Ridge satellite magnetic anomaly have been constructed from bathymetric data. The source magnetizations were assumed to be constant in direction throughout the source region and parallel to the present earth's field at the centre of the source region. The model calculations were made at the observation points of a selected set of MAGSAT investigator-B passes, with a variable magnetic field direction calculated from the MGST(4/81) field model. The horizontal perimeter of all the models was defined by the departure of the Broken Ridge bathymetry from an average oceanic depth of 4.5 km. A comparison of the locations of the model and observed anomaly peaks shows that the Broken Ridge anomaly can be modelled assuming present field directions. There is not sufficient sensitivity in the data to distinguish between the models on the basis of anomaly location. The model magnetizations vary from 0 A/m, where the whole crust is uniformly magnetized, to 42 A/m, where the topographic expression of the ridge is the source of the anomaly. The strength of the required magnetization contrasts cannot be accounted for by induced magnetization if normal oceanic crustal materials are assumed to be the source for the observed anomaly. Measured and modelled remanent magnetizations of sea-floor rocks are typically within the lower part of the range of required values but the higher magnetizations are associated with very young rocks and dredge samples. It is concluded that the source magnetizations have been enhanced by the development of a viscous remanence effect since the last reversal of the earth's field.

J. Geophys. Res., B, Paper 4R1322.

2530 Spatial anomalies (Field modelling)
MAGNAT VERTICAL-FIELD ANOMALIES ABOVE 40°N FROM NUMERICAL-CAM HARMONIC ANALYSIS
A.Y. Haines (Earth Physics Branch, Energy Mines and Resources Canada, Ottawa, Ontario, Canada, K1A 0Y3)

A new technique, the method of spherical-cap harmonic analysis, has provided the means to construct an analytical model of the vertical field above 40°N from Magsat data. With this technique, proper consideration can be taken of altitude variation and of the source-free constraint that the vertical field be the vertical derivative of a potential function. Maps can be produced at any altitude. Here they are given at the lower and upper limits of the Magsat satellite, 6700 and 6900 km radial distances or approximately 325 and 535 km geodetic altitude. A novel decimation procedure, applied to NASA "investigator B" data screened for low disturbance levels, results in an approximately uniform distribution in area, about 1 point per (150 km)². Each of the 5087 data points representing an average over 5 seconds of time or 37 km of satellite track. The harmonic model, of maximum index 22, includes only those basis functions that are necessary for fitting a potential which need not be differentiable to satellite data and that are therefore completely orthogonal over the observed cap. Although there are 276 coefficients in the theoretical model, only 150 were found to be statistically significant. The resulting scatter, or standard error of estimate, was 3.6 nT. (Data decimation, potential field modelling, spherical harmonic analysis, upward continuation, intermediate wavelengths.)

J. Geophys. Res., B, Paper 4B1299

2560
PALEOMAGNETISM OF ROCKS FROM THE BURIN PENINSULA: HYPOTHESIS OF LATE PALEOZOIC DISPLACEMENT OF ACADIA CRITICIZED
E. Irving (Pacific Geoscience Centre, Sidney, B.C. Canada V8L 4B2) and G.F. Strong

The post-tectonic St. Lawrence Granite (360±5 Ma) and associated sub-vertical dikes have two magnetizations, N and R. R points north with an intermediate upward inclination (decl. = 5°, incl. = -50°, alpha (95) = 10°, paleopole 12°N,120°E). We consider R to have been acquired at the time of initial cooling. The N magnetization points south with low inclination. N is also the dominant magnetization in the nearby Permo-Carboniferous Spanish Room Formation. N is considered to be an overprint acquired chemically during the Kiaman Reversed Superchron (Late Carboniferous and Permian). We show that all inclinations observed from Middle to Upper Devonian and Tournaisian rocks from the North American craton are not significantly different either from the Kiaman paleofield, or from the N overprints observed from Newfoundland. We suggest, therefore, that the commonly accepted Late Devonian reference paleofield for North America is either entirely Kiaman in age of has been seriously affected by Kiaman overprinting. Consequently we conclude that arguments which use this reference paleofield as a basis for supposing much of the north-eastern Appalachians (Acadia) displaced 1500 km south-ward relative to the craton in the late Devonian are invalid.

J. Geophys. Res., B, Paper 4B5031.

2599 General (Geomagnetism and Paleomagnetism)
PAR-FOLDING AND OVERPRINT MAGNETIC SIGNATURES IN PRECAMBRIAN (c. 2.9-2.7 Ga) IGNEOUS ROCKS FROM THE PILBARA CRATON AND HAMERSLEY BASIN, W.N. AUSTRALIA
P.W. Schmidt (CSIRO Division of Mineral Physics, P.O. Box 136, North Ryde, NSW, 2113, Australia), B.J.J. Embleton.

A total of 446 oriented samples have been collected from an Archaean intrusion and the Fortescue Group volcanics and intrusions in the Pilbara and Hamersley regions of north-western Australia. The paleomagnetism and rock magnetism of these samples have been investigated using susceptibility and hysteresis properties and both alternating field (AF) and thermal demagnetization. The most consistent paleomagnetic results were achieved by firstly applying AF demagnetization and then step-wise thermal demagnetization. Evidences of the effects of lightning are widespread which accounts for the efficacy of this particular demagnetization strategy. Application constraints on the acquisition ages of some of the magnetizations, and their corresponding pole positions. A pre-folding pole position from the "Millindinna Complex", is Lat = 11.9°S, Long = 161.3°E (dp = 6.8°, dm = 8.4°) and is correlated with a radiometric age of 2.85 +- 0.02 Ga. Folding in the "Millindinna Complex" occurred prior to the deposition of the Fortescue Group. Geochronological data indicate that the extrusion of the flood basalts commenced about 2.8 Ga. This provides a minimum age for the magnetization of the "Millindinna Complex". Deformation responsible for the formation of the mobile belt separating the Pilbara and Yilgarn blocks during the Ophthalmian Orogeny, has affected the Fortescue Group and produced a moderate degree of folding during the "Millindinna Complex" outcrop, the Fortescue Group is generally flat-lying. Pre-folding pole positions from the Fortescue Group are: for the Mount Bruce basalts, Lat = 52.4°S, Long = 178.0°E (dp = 6.4°, dm = 9.1°) and for the Mount Jope Volcanics, Lat = 40.5°S, Long = 128.7°E (dp = 10.9°, dm = 20.6°). The overprint magnetization in the Mount Jope Volcanics yields a pole position, Lat = 35.0°S, Long = 211.7°E (dp = 2.8°, dm = 3.5°) and is interpreted as having been acquired during folding relating to the formation of the Ophthalmian fold belt.

J. Geophys. Res., B, Paper 4B1322.

News

Solar Maximum Mission Highlights

Since the in-orbit repair of the Solar Maximum Mission (SMM) spacecraft, one of the notable discoveries reported is evidence of a 155-day cycle in the occurrence of high-energy solar flares. No pattern to these phenomena had been observed previously. High-energy flares are disruptive to the interplanetary solar wind and are thought to be responsible for geomagnetic storms.

Scientific results based on data from the Solar Maximum Mission (SMM) spacecraft since its repair in April by space shuttle astronauts will be highlighted at the AGU Fall Meeting in San Francisco, Calif., December 3–7, 1984. Eight presentations to be given on the morning of Monday, December 3 will focus on the spacecraft's gamma ray observations, results from the hard X ray burst spectrometer and hard X ray imaging spectrometer, and coronal observations made with the coronagraph/polarimeter.

The SMM spacecraft was launched in February 1980 with an array of instruments designed to help scientists study the physics of solar flares. In November 1980 the spacecraft lost its ability to point accurately toward the sun, rendering some of its specialized instrumentation useless. In April 1984, astronauts aboard a space shuttle flight were successful in repairing the spacecraft's attitude control system, allowing the spacecraft to continue its original mission. The astronauts also were able to repair the electrical box on the SMM's coronagraph. The repair mission was timely; scientists reported that in April and May there was a great deal of solar flare activity, including the largest flare observed since 1978.

Project scientists report that, barring unforeseen problems, the spacecraft should be able to continue its monitoring activities through 1990 before its orbit begins to decay. In addition, mission scientists intend to use the SMM spacecraft to observe Comet Halley. During January through March 1986, Comet Halley will be at its closest approach to the sun. Although the comet will be very difficult to observe from the earth at this time, scientists hope to get a good look at it with the SMM spacecraft.

El Chichón: Stratospheric Chlorine

Two atmospheric scientists have discovered that about 40,000 metric tons of chlorine were injected into the stratosphere during the eruption of the El Chichón volcano in Mexico in March and April 1982. According to the National Center for Atmospheric Research (NCAR), never before had chlorine in the stratosphere been conclusively traced to volcanic sources.

The NCAR scientists who made the discovery, William G. Mankin and M. T. Coffey, said the principle source of stratospheric chlorine was previously believed to be man-made fluorocarbons from activities at the earth's surface. The presence of natural sources of stratospheric chlorine may change the overall view of the chemistry of the ozone layer.

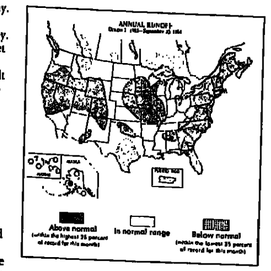
According to the scientists, "The observation that a single, large volcanic event can increase the stratospheric hydrogen chloride burden by 40% over a large part of the globe should lead to a reassessment of the role of volcanoes in stratospheric chlorine chemistry." Previous data collected by Mankin and Coffey over a 5-year period indicate that stratospheric hydrogen chloride has been increasing by about 5% per year, apparently from man-made fluorocarbons. The scientists reported their findings in the October 12 issue of *Science* magazine.

Valles Caldera Research Opportunity

Drilling has been completed at Valles Caldera, N. M., as part of the Continental Scientific Drilling Program (CSDP). The team reports that objectives of the drill (*Eos*, August 14, 1984, p. 474) were met: approximately 168 m of obsidian, several geothermal aquifers, and structural and stratigraphic information, plus widespread hydrothermal alterations, one oriented core, and a suite of geophysical logs. The well now is cased for future research and geochemical sampling.

The well was drilled to a total depth of 856 m, and an unequilibrated bottom hole temperature of 160°C was reached. Core recovery is reported at better than 95%. Hydrothermal alterations include clays, calcite, quartz, pyrite, and chlorite from the volcanic colluvium down to total depth. The intensity of alteration increases with depth and/or along major fractures and faults.

The casing is filled with fresh water, and investigators intend to run thermal gradient logs periodically until May or June 1985. Those interested in obtaining more detailed information or submitting proposals for research should contact Fraser Goff, Los Alamos National Laboratory, ESS-1, Mail Stop D462, Los Alamos, NM 87545.



Streamflow Abundant in 1984

Water was generally plentiful in much of the nation during the 1984 water year, as reflected by the average to above-average streamflows for the 12-month period at 93% of the key index stream-gaging stations across the country, according to the U.S. Geological Survey (USGS). USGS hydrologists said that for the 174 key stations reporting information during the water year, 53% (92 stations) reported flows that were well above average (within the highest 25% of historic record), 40% (70 stations) reported average flows, and only 7% (12 stations) reported streamflow that was well below average (within the lowest 25% of record).

The water year used by hydrologists runs from October 1 to September 30 of the following calendar year and is designed to roughly follow the growing season and to begin and end during a period of generally low streamflow. For the 1984 water year, streamflow was in the upper 25% of record in almost all of the eastern United States, much of the agricultural Midwest, and most of the mountainous western states. Streamflow was consistently below average during the water year in much of Texas and Hawaii and at isolated gaging stations in Florida, Oregon, and Puerto Rico.

USGS hydrologists noted that much of the country has experienced a 2-year wet trend. During the 1983 water year, 48% of the same key index stations had flows that were well above average and only 6% reported well below average flows.

In October 1983—the first month of the 1984 water year—high streamflows were reported in most of the nation, with 90% of the key index stations reporting average to well-above average streamflows. The water year ended on a similarly wet note with 80% of the 174 stations reporting average to above average flows for September 1984.

As a further indication of the generally healthy state of the nation's water resources for the 1984 water year, the combined flow of the three largest rivers in the conterminous United States—Mississippi, St. Lawrence, and Columbia—was 796 billion gallons per day (bgd), 21% above average for the water year. The three large rivers drain more than half of the lower 48 states and serve as a convenient check on the status of the nation's water resources.

The USGS, in cooperation with more than 800 state and local agencies, routinely gathers information on the quantity and quality of the nation's surface and groundwater resources at more than 60,000 sites across the country.

Law/Science Professorship

Columbia University has established a new professorship in law and science in its School of Law. The position, the Julius Silver Professorship in Law, Science, and Technology, is said to be the first chair of its kind at a major law school and was made possible through a gift of more than $1 million. Silver, a graduate of Columbia Law School, is a New York attorney.

Correction

The geographic distribution of AGU members that appeared in the 1984 Membership Directory (*Eos*, August 28, 1984, p. 527) inadvertently included Austria's members with those from Australia. Austria is home to 18 AGU members, Australia to 206.

Editorial

GIFT Needs Larger Donations

Last year we had 16 Life Supporting Members and just over 100 Individual Supporting Members. This year we have 25 Life Supporting Members and close to 200 Individual Supporting Members. This growth is a very satisfying trend; can you help us sustain it? A list of your colleagues who are supporting members will be included with the renewal notice that you will receive shortly. In addition, close to 40% of the membership have donated $10 or more in the last 3 years in response to the request for a voluntary contribution. Thanks to everyone who has done so, and to the others: please help us increase this percentage to more than 50 this year. Voluntary contributions from so many members are a demonstration of appreciation for the Union and help us when we appeal to outsiders.

The GIFT Steering Committee and its parent committee, the Financial Resources Committee, are now actively pursuing contributions from the other organizational members. This effort was launched auspiciously by one of the Corporate Supporting Members of AGU, a company of less than 50 employees, which donated $5000 without even a request from AGU.

The $270,000+ that is now in the Fund looks very good. The GIFT plaque at AGU headquarters now recognizes 32 individuals: one Benefactor who has contributed $10,000, three Sustaining Members at $5000 each, and 21 Life Supporting Members at $1500, plus seven others who have contributed between $1000 and $1500. The committee is now encouraging them to increase their previous contributions and pledges to reach the next level on the plaque. However, there are only 50 members on the plaque; it is much more important that the 15,000 members who are not listed consider whether they could reinvest in AGU some of the dividends that they have earned in geophysics. A pledge of $300 per year over 5 years will make you a Life Supporting Member. AGU needs a significant reserve. The day that the mortgage can be paid off is drawing nearer, and a number of committees have made suggestions for uses of the income from the GIFT Fund that would have direct benefit to the membership. Needless to say, the GIFT Fund Steering Committee will continue its strong efforts to increase the size of the fund, but only you can assure their success.

Charles L. Drake
President

Forum

Acid Rain

Comment

I have read Dr. Lester Machta's article, "Acid Rain: Controllable?" (*Eos*, November 29, 1983, p. 953) and do not want it to go unchallenged.

The final paragraph of the article is hard to justify. I know Dr. Machta, and I think he knows many of my friends, and we are firmly of the opinion that we know enough to justify political action to reduce sulfur emissions now. We also know how to reduce them. Certainly we, as scientists, should work on the residual uncertainties, but in my opinion these are being used as an excuse for inaction politically and do not constitute a valid reason for no action.

The suggestion that a large and expensive field experiment be mounted is surprising in view of the fact that there have been two that have already been done and are well documented. The first was the COMINCO smelter in Trail, B.C., where before World War II the sulfur emissions had made the town and the surrounding country a moonscape. Damage was also claimed by U.S. farmers south of the border. The matter was referred to the IJC, which found COMINCO at fault, awarded damages, and ordered the company to clean up their act. The company did and Trail, B.C., is now a beautiful garden city.

The second example is Sudbury, Ontario. The changes in that city upon the bringing into service of their very high stack are a matter of record.

Finally, I suggest that several of the questions raised by Dr. Machta have already been answered to a sufficient extent by the work done in Sweden and elsewhere in Europe.

To Dr. Machta's "Scientists, politicians, environmentalists, and industrial managers" I recommend the translation by Simon Harper of the report published by the Swedish Ministry of Agriculture for the 1982 Stockholm Conference. It is available from Liber Distribution, 162 89 Stockholm, Sweden, at a cost of 57.50 Krona. It is good reading prepared by a group that have done their homework. The title: "Acidification Today and Tomorrow."

P. D. McTaggart-Cowan
Bracebridge
Ontario P0B 1C0, Canada

Reply

Dr. McTaggart-Cowan's letter states as a fact that enough is now known to take appropriate action to alleviate the transboundary acid rain issue. Others have stated equally as a fact the diametric opposite. I agree that some pollution control measures have already been taken with no more certainty than exists for the acid rain issue. But the costs to society were far smaller than for sulfur dioxide controls. In effect, science only plays part of the role in decisions about environmental protection, and my own personal, preservationist views, which might be shared with you, may not be shared by others.

To address one specific criticism of my article in your letter, may I remind you that the analogy between the long-range transport of acid materials and the Trail smelter problem is not of a nature to substitute it for a modern field experiment. Second, the Sudbury shutdown failed to produce decreases in acidity or sulfate deposition in 1978 and we are still looking into the longer shutdown in 1982–1985. I would criticize my own proposal for a study of deliberate source variation because some versions of this experiment might take a very long time to achieve and in the meantime we are making a decision not to control emissions while we wait.

May I thank you for the reference of the Swedish report, which I shall try to obtain and read.

My last remark in the article pertains to the fact that I neither asked for nor received a clearance for my *Eos* article, and at the time it was prepared I do not believe that the United States had formulated the policy expressed by the President and Mr. Ruckelshaus.

Lester Machta
Air Resources Laboratory
NOAA, Rockville, MD 20852

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For more information, call 202-462-6903 or toll free 800-424-2488.

POSITIONS AVAILABLE

Sponsored Research Staff Member. Sponsored Research Staff position is available in the Department's Earth Resources Laboratory. Duties include interpretation of logging data for non-standard uses such as fracture detection and acoustical mechanical properties; development of tool response models for crystalline rock environments; source rock and permeability studies; development and maintenance of the MIT-ERL well-logging software.

Requirements: MS degree in geophysics plus a minimum of two years field experience in the well-logging industry required. The successful candidate should be familiar with seismic signal processing theory and full-waveform acoustic logging. Experience with multi-variate statistical methods would be very helpful. Operations experience and the desire to work in a research-oriented environment are essential.

Send resume (including salary requirements) to:
Mr. Kenneth Chin
Personnel Office, E19-238
M.I.T.
Cambridge, MA 02139.

MIT is an Equal Opportunity/Affirmative Action Employer.

Physical Oceanographer. The Woods Hole Oceanographic Institution plans to make a tenure track appointment as Assistant Scientist in the Department of Physical Oceanography. Applicants should have a degree in Physical Oceanography or a closely related field and, preferably, some Post-doctoral experience. A candidate's area of expertise in oceanography is not specified, but a working knowledge of fluid dynamics is an important qualification. Please send resume to: The Personnel Manager, Box 54P, Woods Hole Oceanographic Institution, Woods Hole, MA 02543.

An equal opportunity employer M/F/H.

Massachusetts Institute of Technology: Haystack Observatory/VLBI Radio Astronomy. Haystack Observatory invites applications for a one year term appointment, renewable for a second year, for a recent Ph.D. recipient in radio interferometry. Applicants should have an enthusiastic interest in the study of extragalactic and galactic radio sources through VLBI.

Haystack is the site of the Mark III Correlator, and is in the process of adapting a minicomputer for application to imaging and post-processing of astronomical data, including an implementation of AIPS.

The successful candidate will be expected to carry out a research program both independently and in collaboration with Haystack VLBI staff, whose current research programs include multi-meter-length VLBI, both superluminal and stable compact sources, and radio stars. A significant fraction of the researcher's time will be devoted to support of Observatory activities, including processing and post-processing of data from the Mark III Correlator or possibly to support of U.S. VLBI Network observations.

Please write, enclosing resume, to:
J.T. Karaku
Assistant to the Director
Haystack Observatory
Westford, MA 01886.

EDI Engineering & Science. EDI Engineering & Science, a growing and successful firm providing professional and technical services to industry, wishes to make several additions to its geological and hydrogeological staff. Entry level through project manager positions are to be filled. Relocation to Grand Rapids, a recent All-American city. Reply in confidence to: EDI, 911 Cascade West Parkway SE, Grand Rapids, MI 49506.

An EO Employer.

Postdoctoral Fellowship/Coastal Marine Scholar. The Marine Sciences Research Center is seeking recent Ph.D.'s as candidates for a postdoctoral research position in any aspect of marine science, coastal zone management, or related disciplines. Two years of academic year stipend ($18,400 for 10 months) will be provided and scholars are encouraged to pursue their own research interests. Summer support should be available September 1, 1985. All requirements for Ph.D. must be completed by time of appointment. Submit resume, detailed statement of research interests and three letters of recommendation by February 15, 1985 to: Dr. J. Kirk Cochran, Marine Sciences Research Center, SUNY Stony Brook, Stony Brook, NY 11794-5000.

SUNY Stony Brook is an affirmative action/equal opportunity educator and employer. AK#289C-B4.

Senior Research Scientist/Colorado School of Mines. The Geophysics Department, Colorado School of Mines, will have an opening in 1985 for a Senior Research Scientist. The duties of the candidate will be to conduct empirical research in the use of potential fields methods in exploration and to assist graduate students with diverse research projects which are already in progress. The candidate should have a Ph.D. and a minimum of five years experience in potential fields; incustry experience would be an advantage. Please send applications, resume and/or inquiries to Dr. Norman Hurtdill, Acting Director, Center for Potential Fields Studies, Geophysics Department, Colorado School of Mines, Golden, Colorado 80401.

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Faculty Position in Dynamical Oceanography. An academic position (tnure track) is presently available at the assistant or junior associate professor level in the Department of Oceanography, Naval Postgraduate School. An ocean dynamicist experienced in the modeling of mesoscale ocean processes is preferred. The candidate should be competent in the analysis of pertinent observations, and be able to teach a variety of graduate courses in physical oceanography. The applicant should have an earned Ph.D. with an academic background in physical oceanography or a closely related field. Desirable attributes include field experimental interest and experience at sea and/or a strong interest in satellite remote sensing of the ocean. The successful candidate will be expected to each one or two quarters per years, conduct sponsored research, and provide thesis supervision. The access to computer, data archive, and research vessel facilities is excellent. Basic nd applied research opportunities are abundant. Interactions with ocean dynamicists in the Meteorology Department are also possible. Salaries are attractive and are determined by the qualifications of the successful candidate. By 1 January 1985, send a curriculum vitae, bie nnies oand addresses of three references, and a statement of research and instructional interss to:

Professor Christopher N.K. Mooers, Chairman
Department of Oceanography
Naval Postgraduate School
Monterey, CA 93943.

Applicants who are currently doctoral candidate will be considered for appointment as instructors, with a tenure track appointment upon completion of the degree. For additional information, telephone Professor Edward B. Thornton as 408-646-2847.

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Marine Research Scientist. Applications are invited for Principal Investigator position effective January 1985. Doctoral degree and postdoctoral experience required. Candidates should present evidence of grantsmanship and potential for partial support of research in biological, geological or physical disciplines. Send curriculum vitae, ciples of three publications and succint review of previous and proposed research directions to: Dr. Marsh J. Youngbluth, Harbor Branch Foundation, RR 1, Box 196, Fort Peierce, Florida 33450, by 15 December 1984.

Equal Opportunity Employer.

Physical Oceanographer/North Carolina State University. Applications are invited for a nine-month, state funded, tenure track position at the assistant or associate professor level in descriptive physical oceanography. The successful applicant will have a Ph.D., a background inocean circulation and state of the art instrumentation, and will be expected to develop a strong field program and teach graduate level courses. He or she will also have the opportunity of interacting with thirty-two departmental faculty in various areas in oceanography, meteorology and geology. Send curriculum vitae and the names of three references by January 31, 1985 to: Dr. G.S. Janowitz, Chairman, Search Committee in Physical Oceanography, Department of Marine, Earth and Atmospheric Sciences, Box 8208, Raleigh, NC 27695-8208, Telephone 919-737-3711.

North Carolina State University is an equal opportunity/affirmative action employer.

Massachusetts Institute of Technology: Haystack Observatory/Atmospheric Scientist. The Haystack Observatory is accepting applications for an anticipated Atmospheric Scientist position for a one-year period, equivalent to a postdoctoral appointment, to work in the field of upper atmospheric physics with the Millstone Hill Atmospheric Sciences group. The scientist will participate in the analysis of data from multi-technique experimental campaigns performed under the Coupled Thermospheric Mapping Study program being coordinated from Millstone Hill. The applicant should have some experience in an area of upper atmospheric science and familiarity with computers, magnetic tape formats, computer graphics and display techniques. New Ph.D. preferred. Please write, enclosing resume, to:

J.T. Karaku
Assistant to the Director
Haystack Observatory
Westford, MA 01886.

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Image Analysis/Oceanography. The School of Marine Science/Virginia Institute of Marine Science has a two year faculty position for someone with excellent computer skills who would like to help develop a state-of-the-art image-analysis system for applications in marine science; the first priority will be to develop methodology for automated enumeration of plankton samples using multispectral image processing and pattern recognition. The custom-designed system includes optical, color video, and dedicated control/data processing capabilities. The optical system consists of a full range of microscopic capabilities with emphasis on epifluorescence. The video system includes a high sensitivity, high resolution, color video camera which may be intergrated with the microscope or used with a macro lens, and high resolution color monitor. The custom-designed system consists of a high speed microprocessor based computer with an integrated, buss compatible, color video digitizing system capable of acquiring three color video fields simultaneously and also capable of performing digital pattern recognition procedures with those three fields. A printer with color capability is included.

Programming skill in FORTRAN 77, PASCAL, FORTH or C is desirable. This could be a tenure track position for the right individual. Starting salary will range from $20,000 to 25,000/year with full faculty benefits. Openings for graduate assistantships in theis area are also available and student applications to the School are solicited. Interested persons should send a statement of interest, a curriculum vitae and the names, addresses, and telephone numbers of 3-5 referees by 31 December 1984 to Dr. Kenneth Webb, School of Marine Science, College of William & Mary, Glouster Point, VA 23062, Telephone 804-642-7551. Further information may be obtained from Ken Webb at the Fall AGU meeting.

The College of William and Mary is an equal opportunity/affirmative action employer.

Assistant or Associate Professor of Meteorology/University of Illinois. The Department of Atmospheric Sciences, University of Illinois at Urbana-Champaign has an opening for a faculty position effective Fall 1985. It is a tenure track position for the rank of either Assistant or Associate Professor of Meteorology.

Applicants are encouraged from individuals in all specialties of atmospheric sciences. We are particularly interested in applicants whose research activities would augment the departmental research in areas such as climate dynamics, larger scale atmospheric simulation, and synoptic and mesocale meteorology. The prospective faculty member is expected to develop an active research program involving graduate students and to offer a modest amount of teaching of undergraduate and graduate courses with the opportunity of developing courses in his/her specialized field. The salary will be commensurate with the candidate's experience.

The Department has excellent computing facilities and has ready access to a variety of real time meteorological data. In addition, the University of Illinois has a large community of atmospheric scientists who are involved in a variety of research projects at the Illinois State Wauer Survey and the Departments of Electrical and Civil Engineering.

A Ph.D. in atmospheric sciences or other closely related field is required. Those interested should send a resume, a list of publications, a statement of research interests and the names of three references before March 1, 1985 to:

Professor Yoshi Ogura, Head
Department of Atmospheric Sciences
University of Illinois
1101 West Springfield Avenue
Urbana, IL 61801

The University of Illinois is an equal opportunity/affirmative action employer and invites applications from all qualified candidates.

Scripps Institution of Oceanography, Geological Research Division: Stable Isotopes/Sedimentology. Applications are invited for an anticipated opening for an Assistant Research Geochemist. We are looking for candidates with a strong background in chemistry, and an interest in paleoceanography, paleoclimatology, or carbonate geochemistry and sedimentology. Preference will be given to persons experienced in the operation and maintenance of mass spectrometers. Level of appointment and salary will be commensurate with experience, according to University of California standards. Applications and curriculum vitae (2 copies) and references, should be addressed to Drs W.H. Berger or M. Kastner, Scripps Institution of Oceanography, La Jolla, Ca 92093, A-015.

Faculty Position in Applied Geophysics or Structural Geology. The Department of Earth Sciences, University of New Orleans, invites applications for a permanent faculty position commencing August, 1985 in APPLIED GEOPHYSICS or STRUCTURAL GEOLOGY.

The University of New Orleans, located on the south shore of Lake Pontchartrain has 14,00 undergraduate and 2,500 graduate students. The Earth Sciences Department currenlty has a staff of 11 full-time and four part-time faculty and approximately 150 undergraduate geology majors and 50 master's candidates.

The appointee will be expected to teach graduate and undergraduate courses in geophysics-structural geology and general geology, conduct a program of research and supervise theses. The position will be at the assistant professor level. Applications are encouraged from individuals with industrial experience. The Ph.D. degree is required.

Applicants should send a letter outlining interest in position, complete resume, and three letters of recommendation to:

Dr. Louis A. Fernandez, Chairman
Department of Earth Sciences
University of New Orleans
New Orleans, LA 70148

UNO, a member of the Louisiana State University System, is an equal opportunity/affirmative action employer.

Postdoctoral Research Scientist/Lamont-Doherty Geological Observatory of Columbia University. The physical oceanography group has an opening for research on the assimilation of observational data in numerical models of the tropical ocean. The work is part of a larger effort with the long term goal of developing prediction models for interannual climatic variations, especially those associated with El Nino and the Southern Oscillation. A Ph.D. is required. The ideal candidate would have knowledge of physical oceanography, numerical weather prediction, applied mathematics and control theory. A strong background in one of these areas is required.

Send curriculum vitae and the names of three references to: Dr. Mark Cane, Lamont-Doherty Geological Observatory, Palisades, NY 10964.

Lamont-Doherty is an equal opportunity/affirmative action employer.

Seismologist/Ohio State University. The Department of Geology and Mineralogy, The Ohio State University, invites applications for a tenure track position for a seismologist with research interest in crustal geology and tectonics. The successful applicant must be prepared to assist in teaching exploration geophysics courses, advanced topics in his/her speciality, conduct research, and supervise graduate students. Postdoctoral or industrial experience is desirable. Rank and salary commensurate with experience and research record. Please send applications or nominations to:

Dr. Ralph R.B. von Frese
Chairman, Search Committee
Department of Geology and Mineralogy
The Ohio State University
Columbus, OH 43210
Telephone: 614-422-5635 or 422-7221.

Applications should include a resume, a statement of research interests and the names and addresses of at least three persons whom we may contact for recommendations. The closing date for applications is December 1, 1984; or until position is filled; appointments can be effective as soon as October 1, 1985. Additional information can be obtained by writing or calling the chairmain of the search committee.

The Ohio State University is an equal opportunity/affirmative action employer.

Astronomy/Magnetospheric/Planetary/Digital Imaging Scientists. This is an opportunity to become involved in state-of-the-art data management issues, techniques, and solutions while simultaneously pursuing research interests. The National Space Science Data Center at the Goddard Space Flight Center is in an exciting transitional period and has three new openings on its contract staff for data oriented scientists in the above areas. These individuals will join with several others in attacking a broad range of activities, primarily intended to facilitate access to and utility of space science data in an evolving technological environment. These activities include development of an online data catalog, interfacing with Principal Investigators and spacecraft project offices for data accessibility and documentation, preparing data catalogs, generating techniques for coordinated multi-spacecraft data acquisition and analysis, and generation of supporting on- or other value-added data sets. Research interests are encouraged and may be pursued on a substantial part-time basis. A Ph.D is prefered, although a Master's degree will be considered for some activities. Experience with space flight experiments, data analysis techniques, data presentation, publications, and programming is highly desirable. Specific duties will depend upon an individuals background and interest. Send resume to: Linda Williamson
Signa Data Services Corp., a M/A-COM Co.
Code 633
National Space Science Data Center
NASA/GSFC
Greenbelt, Md. 20777
(301) 344-8148.

Signa Data Services Corp., a M/A-COM Co. is an equal opportunity affirmative action employer.

University of Illinois at Chicago. The Department of Geological Sciences seeks to fill tenure track positions probably, but not necessarily, at the rank of assistant professor, probably effective Fall, 1985, pending budgetary approval, in one or both of the following disciplines: (1) geophysics (preferably in seismology); 2) sedimentary geochemistry. Each person is expected to teach both undergraduate and graduate courses and to conduct a vigorous research program, including the supervision of graduate students. PhD required. Applicants should submit a detailed resume, names and addresses of three references, and an explanatory statement of research and teaching interests by February 28, 1985, to Robert DeMar, Department of Geological Sciences, University of Illinois at Chicago, Chicago, Illinois 60680. Representation of the Department will be at the Fall Meeting in December.

The University is an equal opportunity/affirmative action employer.

Sedimentary Petrologist/Wright State University. The Department of Geological Sciences invites applications for a tenure track position in sedimentary petrology, at the assistant professor level beginning September 1, 1985. Candidates must have an interest in carbonate rocks and basin analysis. Preference will be given to people capable of teaching introductory paleontology. The Department has a large M.S. program and wishes to expand its sedimentary petrology group. Applicants should expect to complete all requirements for the Ph.D. in geological sciences or related field by September 1, 1985. Send resume and three letters of reference to Chairman, Search Committee, Department of Geological Sciences, 260 Brehm Laboratory, Wright State University, Dayton, Ohio 45435. Closing date for applications is January 15, 1985.

Wright State University is an equal opportunity/affirmative action employer.

University of Wyoming/Department of Geology and Geophysics. The Department of Geology and Geophysics encourages applications from students interested in pursuing graduate research in the fields of igneous and metamorphic petrology and geochemistry. Current research topics, involving field and laboratory studies, include: island arc and continental volcanics, petrogenesis of granitic and anorthositic rocks, evolution of the Archean crust, petrogenesis of mylonitic rocks, and geothermometry and geobarometry as applied to the evolution of orogenic terranes. Facilities include an analytical geochemical lab for whole-rock and trace element analysis, a fully automated CAMECA microprobe, two JOEL scanning electron microscopes, a thermal ionization mass spectrometer for analyzing Rb-Sr, Sm-Nd, and U-Th-Pb isotopes, a microthermometry lab, and an experimental petrology lab. Applicants should contact:

Petrology/Geochemistry Program
Department of Geology and Geophysics
PO Box 3006, University Station
University of Wyoming
Laramie, WY 82071

University of Utah: Structual Geology/Tectonics/Tectonophysics. The Department of Geology and Geophysics at the University of Utah seeks applications for a tenure track position in structural geology, tectonics or tectonophysics. It is anticipated that this position will be filled at the assistant professor level, but applications by more senior persons will be considered. The position requires a Ph.D. with emphasis in structural geology, regional tectonics or tectonophysics. The new faculty member will have the opportunity to teach in the area of his or her specialty and may also be assigned introductory level courses. The successful candidate will be expected to establish a vigorous research program involving graduate students. The person who fills this position will join an active program in structural geology and tectonics that includes both field projects and integrated geology/geophysics and mechanics/fluid chemistry studies of structures in the western Cordillera. There is an excellent opportunity to collaborate with other faculty in structural geology, sedimentology, geophysics, geochemistry and petrology. A vita, copies of publications, names of three persons that may provide references, and a letter outlining the candidate's research and teaching interests should be sent to Dr. William P. Nash, Chairman, Department of Geology and Geophysics, University of Utah, Salt Lake City, Utah 84112-1183. Deadline for receipt of applications is December 31, 1984 with the appointment starting in September 1985

The University of Utah is an equal opportunity/affirmative action employer.

EOS

Transactions, American Geophysical Union

The Weekly Newspaper of Geophysics

For speediest treatment of contributions, send three copies of the double-spaced manuscript to one of the editors named below and one copy to AGU.

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Cover. Reflected light micrograph of a polished and etched surface of an experimentally deformed rock salt sample from the Asse mine, Federal Republic of Germany. Old grains with a considerable amount of dislocation substructure are being replaced by strain-free idioblastic new grains. Although grain boundary migration in dry salt is negligible up to 600°C, in natural material (which invariably contains small amounts of brine) it can be significant at temperatures as low as 50°C. Grain boundary mobility is strongly enhanced by the formation of thin brine films on grain boundaries, increasing the grain boundary diffusion coefficient by several orders of magnitude. This fluid-enhanced grain boundary migration may be an explanation for the recrystallized microstructures found in most salt deposits. Scale bar is 0.1 mm. The sample is deformed at 150°C and 15 MPa confining pressure. The strain rate was 10^{-6} s^{-1}, followed by stress relaxation. (Micrograph courtesy of J. L. Urai, Department of Geological Sciences, SUNY at Albany, N. Y., and C. J. Spiers and G. S. Lister, Department of Structural Geology, I.V.A.U., Utrecht, The Netherlands.)

Computer Manager/Minicomputer Specialist. Memphis State University seeks a candidate to manage a PDP 11/44 and a major facility expansion to include a supermini/microcomputer system (VAX 11/ 785 class) to be dedicated to research applications in the Geological Sciences and Geophysics. Hardware and software are designed for digital seismic data acquisition, digital seismic data processing, and graphical representation of geological and geophysical data.

The candidate must have at least a BS degree in Computer Science, Electrical Engineering or related field; three years programming experience including FORTRAN and ASSEMBLY; knowledge of various computer hardware and two or more widely used operating systems that includes both field projects and integrated geology/geophysics and mechanics/ fluid chemistry studies of structures in the western Cordillera. There is an excellent opportunity to collaborate with other faculty in structural geology, sedimentology, geophysics, geochemistry and petrology. A vita, copies of publications, names of three persons that may provide references, and a letter outlining the candidate's research and teaching interests should be sent to Dr. William P. Nash, Chairman, Department of Geology and Geophysics, University of Utah, Salt Lake City, Utah 84112-1183. Deadline for receipt of applications is December 31, 1984 with the appointment starting in September 1985

The University of Utah is an equal opportunity/affirmative action employer.

Chairperson/The University of Tulsa, Department of Geosciences. Nominations and applications are invited for the position of Chairperson. Candidates should have a Ph.D. and a distinguished record of teaching and research. Leadership and administrative skills and experience to interact effectively with academics, industry and alumni are required.

The department of geosciences has ten faculty members and is located in a new building and research complex. There is a strong emphasis on soft rock geology and exploration geophysics in the department which has grown steadily in the last decade. Equipment includes a VAX 11-750 computer with an array processor and seismic data processing software, SEM, Microprobe, XRF, XRD, gas chromatographs and a mass spectrometer. Library resources which are supported by "Petroleum Abstracts" are excellent.

Nominations and applications should be sent to: Colin Barker, Department of Geosciences, University of Tulsa, 600 South College, Tulsa, Oklahoma 74104 by January 16, 1985.

The University of Tulsa is an equal opportunity/ affirmative action employer.

The Department of Geology and Geophysics at the University of Minnesota/Senior Faculty in Large Scale Scientific Computing. The Department of Geology and Geophysics and other science and engineering departments of the Institute of Technology of the University of Minnesota invite applications and nominations to fill a number of senior faculty positions in large scale scientific computing. Depending on the qualifications of the candidates, these positions will be based in one or more of the university science and engineering departments of the Institute of Technology, as part of the academic research and instructional components of the University of Minnesota Supercomputer Institute.

This Institute is a newly formed, developing, University-wide unit, to be operated under the aegis of the Institute of Technology, and is to be the center of academic instructional and research activities in large scale computing in the University.

A succesful candidate must have demonstrated research accomplishments and intellectual leadership in a disciplinary and inter-disciplinary area of large scale scientific computing. Faculty rank and remuneration are dependent on experience, qualifications, and accomplishments. Applicants whose primary research interests lie in the field of Geology and Geophysics should send resumes to George H. Shaw, Chair—Search Committee, Department of Geology and Geophysics. The Department of Geology and Geophysics will nominate one or more of these applicants and forward these nominations to the Dean of the Institute of Technology for final evaluation. The last date for receipt of applications, including a statement of interest and curriculum vitae, and names of appropriate professional references, and names of appropriate professional references is January 31, 1985, but departments will begin to review applications on November 26, 1984.

The University of Minnesota is an equal opportunity educator and employer and specifically invites and encourages applications from women and minorities.

Texas Tech University/Geophysicist or Clastic Sedimentologist. The Department of Geosciences at Texas Tech University seeks applications for a tenure track position in the fields of geophysics or clastic sedimentology to begin August 1985. Rank and salary will be commensurate with qualifications. The Ph.D is required. Entre-level applicants will be given preference. The primary responsibility would be to teach introductory and undergraduate courses in geophysics or depositional systems and sedimentology, his/her specialty, and introductory geology. The person will be expected to initiate a research programs and to direct MS and Ph.D. graduate students. Send a letter of application with complete curriculum vitae and names of three references to Dr. Alonzo D. Jacka, Chairman of Geosciences, P.O. Box 4109, TTU, Lubbock, TX 79409.

Texas Tech is an equal opportunity/affirmative action employer. Applications deadline: January 31, 1985.

Chairperson/The University of Tulsa, Department of Geosciences. Nominations and applications are invited for the position of Chairperson. Candidates should have a Ph.D. and a distinguished record of teaching and research. Leadership and administrative skills and experience to interact effectively with academics, industry and alumni are required.

The department of geosciences has ten faculty members and is located in a new building and research complex. There is a strong emphasis on soft rock geology and exploration geophysics in the department which has grown steadily in the last decade. Equipment includes a VAX 11-750 computer with an array processor and seismic data processing software, SEM, Microprobe, XRF, XRD, gas chromatographs and a mass spectrometer. Library resources which are supported by "Petroleum Abstracts" are excellent.

Nominations and applications should be sent to: Colin Barker, Department of Geosciences, University of Tulsa, 600 South College, Tulsa, Oklahoma 74104 by January 16, 1985.

The University of Tulsa is an equal opportunity/ affirmative action employer.

Marine Geophysicist/Texas A&M University. The Department of Oceanography invites applicants for a tenure track position in an geological/geophysical section in the general field of marine geophysics and global tectonics. A Ph.D. is required. Rank and salary of the position are open. The successful applicant will be expected to initiate a vigorous research program, have an interest in seagoing activities, and interact with colleagues in the Departments of Oceanography, Geophysics, and the Geodynamics Research Program. Duties will also include the teaching of M.S. and Ph.D. students. The position is available beginning September 1, 1985. Applicants should submit a detailed resume including names of references and statement of research interests to T. K. Treadwell, Faculty Search Committee Chairman, Department of Oceanography, Texas A&M University, College Station, Texas 77843. Closing date for applications is January 15, 1985.

Texas A&M University is an equal opportunity/affirmative action employer.

The University of Minnesota: Structual Geology/Tectonics. The University of Geology and Geophysics invites applications for a new, tenure track position in structural geology and tectonics. Candidates will be expected to carry out an active research program in their field of interest and to assume teaching and advising responsibilities at the undergraduate and graduate levels. A Ph.D. is required. The position will be available fall 1985. Application deadline is February 15, 1985. Applicants should send curriculum vitae, list of publications, statement of research interests, and names of at least three referees to Peter Hudleston, Chairman, Department of Geology and Geophysics, University of Minnesota, Minneapolis, Minnesota 55455.

The University of Minnesota is an equal opportunity educator and employer and specifically invites and encourages applications from women and minorities.

Middlebury College/Metamorphic Petrologist. The Department of Geology seeks a metamorphic petrologist with an interest in tectonics. The regular (tenure-track) entry-level position requires the PhD and begins in the fall of 1985.

The 4-member department maintains active research and an ongoing field and lab program with students in tectonics, petrology, and oceanography. Teaching responsibilities normally include 2 semester-courses, a 1-month winter term course, and supervision of senior research. The department has an NMR/MAT laboratory and an automated electron microprobe.

Send application, including resume, research interests, transcripts, and 3 current letters of reference to: Brewster Baldwin, Chairman, Department of Geology, Middlebury College, Middlebury VT 05753. Application deadline is February 1, 1985.

Middlebury College is an equal-opportunity employer.

Physical Oceanography, Postdoctoral Fellow. One to three year appointment for person(s) interested in under-ice coastal circulation and/or boundary layer dynamics. Ph.D. in physical oceanography required. Position available approximately 1 January 1985. Resumés with names of three references should be sent to Dr. R. G. Ingram, Oceanography, McGill University, 3620 University St., Montreal, Qué. H3A 2B2 Canada.

All applicants are encouraged to apply but preference will be given to Canadian citizens and permanent residents.

High Altitude Observatory Scientific Visitor Program/NCAR. Scientific visitor appointments at the High Altitude Observatory are available for new and established Ph.D's for up to one year to carry out research in solar physics, solar-terrestrial physics, and related subjects. Applicants should provide a curriculum vitae, including education, work experience, publications, the names of three scientists familiar with their work, and a statement of their research plans. Applications must be received by 15 January 1985 and they should be sent to: The HAO Visitor Committee, High Altitude Observatory, National Center Atmospheric Research, P.O. Box 3000, Boulder, Colorado 80307-3000.

NCAR is an Equal Opportunity/Affirmative Action Employer.

Northern Arizona University/Department Chairperson. Chairperson, associate or full professor, Department of Geology, Northern Arizona University, beginning summer 1985. Specialty open but preference will be given to applicants with a strong background in tectonics and tectonic problems. Applicants must be capable of interacting professionally with an active and diverse faculty of 14 geologists and geophysicists. Candidates should expect to continue an active research program, should have administrative capabilities and a dedication to quality teaching. The Department has been granted planning status to apply for a PhD program so it is essential the successful candidate possess the desire to guide the Department through the final planning stages. NAU has a traditional emphasis on field problems in the Colorado Plateau and adjacent areas but we are expanding our analytical facilities to improve theoretical and experimental capabilities. Salary will be competitive and negotiable. Additional duties include teaching and supervising graduate student research. Application deadline: January 15, 1985. Send curriculum vitae, statement of research interests and names of four professional references to Search Committee—Chair, Department of Geology, Box 6030, Northern Arizona University, Flagstaff, AZ 86011.

Northern Arizona University is an equal opportunity/affirmative action employer.

Sedimentologist-Oceanographer/Texas A&M University. Applications are invited for a tenure track faculty position in the general field of marine sedimentology. The position will involve graduate level teaching and supervision of graduate student research. The successful applicant will have demonstrated excellence in or a strong potential for independent research in the field of marine sedimentation. The position is available beginning September 1, 1985. Salary and rank will be commensurate with experience and qualifications. Applicants are invited to submit curricula vita, copies of publications, names of three persons who may serve as references, and a letter outlining the applicant's teaching and research interests by December 31, 1984, to Robert O. Reid, Distinguished Professor and Head, Department of Oceanography, Texas A&M University, College Station, Texas 77843.

Texas A&M University is an affirmative action/ equal opportunity employer.

Geochemistry. The University of California, Davis will fill a permanent, tenure track, faculty position at the assistant professor level beginning Fall, 1985. Candidates having interests in isotope geochemistry and/or the geochemistry of economic deposits are especially encouraged to apply but other specialties in geochemistry will be considered. A PhD degree is required. Responsibilities include teaching at the undergraduate and graduate levels, and research in geochemistry.

Applicants should submit complete vita, a statement of research and teaching interests and the names of three referees. Deadline for application is January 15, 1985. Inquiries and applications should be directed to: Dr Howard W. Day, Department of Geology, University of California, Davis, CA 95616.

The University of California is an equal opportunity/affirmative action employer.

Coastal Physical Oceanographer. The College of Marine Studies invites applications for a tenure track position in physical oceanography. Applicants should have a background in coastal or estuarine physical oceanography, with experience in observational work at sea. The successful applicant will have the opportunity to develop an independent oceanographic research program which may include carrying out physical oceanographic research within existing interdisciplinary research programs in Delaware Bay or the adjacent continental shelf. Facilities available include the 120-foot coastal research vessel Cape Henlopen. Teaching at the graduate level will be required, and the successful candidate will be expected to develop a funded research program involving graduate students. It is anticipated that the appointment will be at the assistant professor level, but applications from more senior persons are welcome. Applicants should send curriculum vitae, pertinent reprints, and the names of three references to the chairman of the search committee: Dr. Richard Garvine, Oceanography Program, College of Marine Studies, UNIVERSITY OF DELAWARE, Newark, DE 19716. (302) 451-2169. The closing date for applications is November 30, 1984.

The University of Delaware is an equal opportunity/affirmative action employer.

Seismologist/University of Illinois. Applications are solicited for a tenure-track position at the Assistant Professor level in seismology. A creative individual is sought who will develop a research program that complements our existing programs in seismology (currently emphasizing source properties), geodynamics, tectonics, and rock/mineral physics. An excellent research environment and outstanding facilities are available both in the Department and the University. A Center for Super Computer Research and Development is presently being formed at the University. In addition, our campus is the site of a proposed regional computational facility. Opportunity exists to interact with the department of Theoretical and Applied Mechanics. The position is expected to be filled as early as Fall, 1985. Salary is commensurate with experience; a PhD is required. The successful candidate is expected to participate in teaching and advising at the graduate and undergraduate levels. For equal consideration, interested individuals should send curriculum vitae, list of publications, statements of research interests and names of three or more references by December 15, 1984 to:

Professor Albert T. Hsui
Department of Geology
University of Illinois at Urbana-Champaign
1301 W. Green Street
Urbana, Illinois 61801
Tel: 217/333-7792 or 333-3542.

The University of Illinois is an equal opportunity/affirmative action employer.

Assistant Professor—Isotope Geochemistry/The University of Minnesota. The Department of Geology and Geophysics at the University of Minnesota, Minneapolis, invites application for a 3 to 5 year position at the level of Assistant Professor in isotope geochemistry beginning Fall 1985. We are seeking someone with a Ph.D. and preferably some post-doctoral experience, an individual who will be active in research and teaching in addition to the operation of an existing solid-source mass-spectrometry laboratory. The geochemistry program at Minnesota emphasizes its interconnectedness with the in-house programs in igneous and metamorphic petrology, tectonics, hydrogeology and limnology. The holder of this position is expected to continue this tradition in addition to cooperating with or complementing the existing geochemistry research programs in aqueous geochemistry, stable isotopic geochemistry, and noble gas geochemistry, particularly in the areas of ore genesis, rock-water interaction, and mantle evolution.

Please submit a letter of application and attach a curriculum vita, a statement of research and teaching interests, a list of publications and the names of three to five references. Address your correspondence by *February 28, 1985*, to Emi Ito, Department of Geology and Geophysics, University of Minnesota, 310 Pillsbury Drive, S.E., Minneapolis, MN 55455.

The University of Minnesota is an equal opportunity educator and employer and specifically invites and encourages applications from women and minorities.

Assistant Professorship in Observationl Coastal Dynamics/University of North Carolina Institute of Marine Sciences, Morehead City. Tenure track position for a physical scientist with interests in neashore (continental shelf and/or estuarine) circulation will be availabel on July 1, 1985. This will be a research position, carrying a nine-month state supported salary commenturate with experience. The appointee will be expected to develop and carry out a field program in nearshore circulation. This person will be staffed at a research laboratory swhere programs related to coastal dynamics are underway. These programs include sutdies of sediment dynamics, sediment/water chemical exchanges, plankton patchiness and larval dynamics. The appointee will also interact with faculty and students in an academic Curriculum in Marne Sciences at Chapped Hill. Faculty in this unit conduct research on carbonate platform geology, Gulf Stream dynmics and sediment/water chemical exchanges.

Interested applicants should send a letter describing their research interats, a curriculum vitae and names of four references to Dirk Frankenber, Director Institute of Marine Sciences, 3407 Arendell Street, Morehead City, NC 28557 by January 4, 1985.

The University of North Carolina is an affirmative action/equal opportunity employer.

University of South Carolina. Two year postdoctoral research assistant position anticipated. Person should have a strong background in structural geology of completely deformed regions along with an interest in geologic mapping and integration of diverse kinds of geologic and geophysical data. Starting date as early as January 15, 1985. Closing date for applications December 31, 1984. Applications for additional information should be sent to Prof. Robert D. Hatcher, Jr., Department of Geology, University of South Carolina, Columbia, SC 29208.

The University of South Carolina is an affirmative action/equal opportunity employer.

Graduate Fellowships/University of Oklahoma. The School of Geology and Geophysics offers fellowhips for Ph.D. study in each of the following broad disciplines: (1) origin, ascent, and fractionation trends in magmas and associated ore deposits; (2) formation and tectonic evolution of continental lithosphere, including geophysical properties and structures of the upper crust; and (3) sedimentary processes, including organic and inorganic diagenesis, evolution of hydrocarbons, and correlation using biostratigraphic methods. Average fellowship stipends are for $10,000/9 month and are renewable annually on a competitive basis. Fellowship awards include a waiver of out-of-state tuition and fees.

The School of Geology and Geophysics presently consists of 19 full-time faculty. Research facilities in the school include a stable isotope laboratory; organic geochemistry laboratory; computer automated X-ray diffraction and fluorescence equipment; atomic absorption and neutron activation analysis equipment; scanning electron microscope with energy dispersive analyzer; transmission electron microscope; fission-track dating laboratory; fluid inclusion microthermometry laboratory; 2 kb hydrothermal laboratory for phase equilibrium experiments; high-pressure rock mechanics laboratory; paleomagnetic laboratory with a cryogenic magnetometer and thermal and AF demagnetization apparatus; 24-, 48-, and 192-channel digital seismic recording systems; a VAX 11-785 computer with high-resolution graphics and image-display terminals, with seismic and image processing software; and a 84,000 volume geology and geophysics library located in the department.

For further information on faculty and active research projects, contact: Kevin Crowley, School of Geology and Geophysics, University of Oklahoma, 830 Van Vleet Oval, Norman, OK 73019.

Seismologist/University of Utah. The Department of Geology and Geophysics at the University of Utah seeks applicants for a tenure track faculty position in seismology at the assistant to associate professor level. Applicants with backgrounds and specialties in seismic imaging, seismic reflection or theoretical seismology will be given preference. The individual will be expected to teach undergraduate and graduate courses and to pursue an active research program with graduate students. A seismic imaging laboratory with a VAX 11/750, FPS array processor, plotters, and processing and synthetic seismogram software is available to the successful candidate. Current research in seismology includes: earthquake research utilizing a PDP 11-70 computer; monitoring of the Intermountain seismic belt by an 85 station telemetered network utilizing an on-line PDP 11-34 computer; major experiments in seismic refraction and reflection profiling for crustal structure; and allied research in tectonophysics. The opportunity exists to participate with several other faculty in an integrated program of tectonics, seismology and sedimentology directed toward crustal studies and petroleum exploration. The geophysics component of the department has active research and teaching programs in electrical and electromagnetic methods, thermal properties of the earth, potential fields, and seismology. The department has close associations with the numerical analysis and data processing groups in computer science, electrical engineering and mathematics. The closing date for applications is December 31, 1984, and the appointment date is September 15, 1985. A Ph.D. is required for this position. Applicants should submit a vita, transcripts, a letter describing his/her research and teaching goals and names of five persons for reference. Qualified persons should send their applications to William F. Nash, Chairman, Department of Geology and Geophysics, University of Utah, Salt Lake City, Utah 84112-1183.

The University of Utah is an equal opportunity/affirmative action employer.

Duke University/Structual Geology. The Department of Geology invites applications for a senior-level tenured faculty position in structural geology. We are seeking an individual with a proven research record and international recognition in his/her field. The Department has active research programs in geophysics, sedimentology, geochemistry, igneous petrology, carbonate petrology, marine geology and paleontology; graduate programs for both the MS and PhD degrees are offered. Applicants should send a curriculum vitae and names and addresses of six references. The position is to be filled by September, 1985. Closing date for applications and nominations is December 31, 1984. Applications, nominations and inquiries should be directed to Chairman, Search Committee, Department of Geology, Duke University, P.O. Box 6720 College Station, Durham, NC 27708.

Duke University is an equal opportunity/affirmative action employer.

Satellite Altimetry; Department of Commerce, National Oceanic and Atmospheric Administration (NOAA). The National Ocean Service, Office of Charting and Geodetic Services announces a vacancy for the position of Geodesist, GS-1372-15. The position is in the Satellite and Ocean Dynamics Section of the National Geodetic Survey, Rockville, Maryland. This research position will involve analysis of satellite altimeter data for application to ocean dynamics and geodynamics. Applicants should have a detailed knowledge of altimetry, marine geodesy, and physical oceanography, including concepts of geostrophic circulation and planetary wave theory. Investigations will be concerned with sea height variability, equatorially trapped waves, assimilation of altimeter data into numerical models, and other topics of importance to established national programs in ocean and climate studies. The position requires a demonstrated ability to do scientific research as evidenced by publications in the literature. A Ph.D. in physical sciences or equivalent is desirable. Persons interested in applying may request a copy of the vacancy announcement which contains qualification requirements, by writing to Ms. Louise Turner, RAS/DC25, NOAA, National Ocean Service, Rockville, Maryland 20852, or by calling 301-443-8998. Applications should be submitted on Standard Form 171. Closing date for applications is 12-10-84.

Department of Commerce is an equal opportunity employer. U.S. citizenship required.

Faculty Position in Structural Geology/Tectonics. The Department of Marine, Earth and Atmospheric Sciences, North Carolina State University, has a tenure track opening at the Assistant or Associate Professor level in the area of structural geology/tectonics. The position will be filled for the beginning of the Fall 1985 term. The department currently has 31 full-time faculty, including 12 geologists and geophysicists.

The successful applicant will be expected to have completed the PhD degree. Courses to be taught include undergraduate structural geology as well as courses in structural analysis, tectonics, or other areas of research activity. He or she additionally will be expected to develop a vigorous program of sponsored research and to direct graduate student research projects at the MS and PhD level.

Please send complete resume and the names of at least three references to V.V. Cavaroc, Search Committee Chairman, Department of MEAS, North Carolina State University, Raleigh, NC 27695-8208; phone (919) 737-2212. Applications will be considered as received, with a closing date of January 15, 1985.

North Carolina State University is an equal opportunity/affirmative action employer.

Ph.D. Fellowships/Louisiana State University. Applications are invited from prospective Ph.D. students in all fields of geology and geophysics for fellowships in the Department of Geology, Louisiana State University. The stipends, provided by Atco, Exxon, and the LSU Alumni Federation, range from $10,000 to $13,500 per year; the awards are made on an annual basis and are renewable for up to three years. One of the benefits of these fellowships is the remission of tuition and fees to about $100 per semester.

Applications (plus transcripts, GRE scores, and three letters of recommendation) must be received by March 15, for the Alumni Federation Fellowships, however, the Departmental deadline for receipt of application package is January 7.

Application materials and further information on the graduate program can be obtained from:

Baum K. Sen Gupta
Director of Graduate Studies
Department of Geology
Louisiana State University
Baton Rouge, LA 70803-4101.

Louisiana State University is an equal opportunity/affirmative action employer.

The Johns Hopkins University/Paleontologist. The Department of Earth and Planetary Sciences invites applications for a tenure-track faculty position, effective July 1, 1985, for a paleontologist whose research will strengthen the link between our paleontology and sedimentology programs. The appointee will be expected to develop an innovative research program, and responsibilities will include undergraduate and graduate teaching and the supervision of doctoral candidates.

To apply, send curriculum vitae, publications list, and the names of at least three referees to Dr. John M. Ferry, Department of Earth and Planetary Sciences. The Johns Hopkins University, Baltimore, MD 21218, U.S.A. The application deadline is January 15, 1985.

The Johns Hopkins University is an equal opportunity, affirmative action employer.

Geochemistry/University of Hawaii. Hawaii Institute of Geophysics and Department of Geology and Geophysics invite applicants for a tenure track position in geochemistry. The position is a joint one between institute and department, and will be filled at the level of Assistant Professor or Associate Professor. The purpose of the appointment is to supplement existing teaching and research programs in volcanology and petrology, and preference will be given to applicants with a record of research in one or more fields from among: trace-element geochemistry, applied geochronology, other isotope geochemistry, experimental studies in petrology, and field or igneous rocks. The appointee will be expected to offer a survey of geochemistry for advanced undergraduate and beginning graduate students, to contribute to the offering of introductory-level courses as well as to graduate courses in the appointee's specialty, to pursue an active research program, to guide graduate students, and to interact with faculty and staff as appropriate.

A letter of application, with resume, bibliography, and names and addresses of three persons willing to comment about your qualifications and promise, should be sent to: Geochemistry Search Committee, Attn: Michael Garcia, Hawaii Institute of Geophysics, University of Hawaii, Honolulu, Hawaii 96822. Closing date for applications is February 1, 1985, with appointment to commence July 1, 1985 or at some nearby date if mutually agreeable between the applicant and us.

We encourage applications from women and members of minority groups. The University of Hawaii is an equal opportunity employer.

Faculty Position. The Department of Earth and Space Sciences, SUNY Stony Brook invites applications for a tenure track faculty appointment. Rank and salary will be dependent on qualifications. Areas of specialization are open but preference will be given to applicants whose research interests complement those of the sedimentary geology program in the areas of: 1) quantitative modeling of heat and mass transfer on a regional or global scale; or 2) low-temperature geochemistry, sedimentary petrology, economic geology, hydrogeology. The successful candidate must have a Ph.D., a demonstrated research potential and an interest in teaching graduate and undergraduate students. Qualified persons should send a resume and arrange for three references to be sent to: Dr. G.N. Hanson, Chairman, Department of Earth and Space Sciences, SUNY Stony Brook, Stony Brook, NY 11794-2100.

SUNY Stony Brook is an affirmative action/equal opportunity educator and employer. AK#300-84.

Meetings

Announcements

Tectonics

December 17–21, 1984 Tectonic Studies Group 15th Annual General Meeting, Swansea, U.K. Sponsor: Univ. College of Swansea. (Richard Lisle, Dept. of Geology, Univ. College, Swansea SA2 8PP, United Kingdom.)

This meeting will include 3 days of discussions of current research in structural geology, with poster displays and short lectures, during December 18–20. Workshops and local field trips will take place on December 17 and 21.

ODP Drilling

February 20–22, 1985 Workshop on ODP Drilling in the Northeast Pacific, Seattle, Wash. Sponsor: International Northeast Pacific Activities Consortium (INPAC). (Paul Johnson, School of Oceanography WB-10, Univ. of Washington, Seattle, WA 98195; tel.: 206-543-8474.)

Those interested in attending should contact the convenor (given above) before December 1, 1984.

This workshop aims to further define a drilling program in the northeast Pacific which will use the new ODP drilling ship *SEDCO/BP 471*, to define those major scientific problems that can be addressed by drilling, to identify possible drill sites, to present the results of ongoing scientific programs in the area, and to organize the data collection and synthesis necessary to write a comprehensive drilling proposal for submission to the Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES). The threefold purpose of the proposed drilling program will include ridge crest processes on the Juan de Fuca Ridge, convergent margin processes off the coasts of Washington, Oregon, and British Columbia, and paleo-oceanography of the northeast Pacific.

LPI Conference

March 11–15, 1985 16th Lunar and Planetary Science Conference, Houston, Tex. Sponsors: Lunar and Planetary Institute, AGU, NASA Johnson Space Center, Division for Planetary Science of the American Geological Society of America, Meteoritical Society. (Pamela Jones, Conference Administrator, Lunar and Planetary Institute, 3303 NASA Road 1, Houston, TX 77058; tel.: 713-486-2150.)

The deadline for the submission of abstracts is January 15, 1985.

The scope of this conference is quite broad. Suggested topics for papers range from asteroids and comets to lunar geodesy, from cosmic rays to planetary physics and tectonics, from remote sensing to crustal genesis. A special session on international research is also planned.

Surveying

June 9–16, 1985 52nd Session of the Permanent Committee of the International Federation of Surveyors (FIG), Katowice, Poland. (Komitet Organizacyjny PO 86, ul. Kossutha 9, PL 40-833 Katowice, Poland, PO 108.)

The deadline for the submission of one-page abstracts is December 31, 1984.

The principal aim of the meeting is to provide an opportunity for discussion between specialists in the field and to permit exchange of the information and new developments obtained since the 6th International Symposium on Geodetic Computations, which was held in Munich in 1981. New research trends in methods and techniques for geodetic computations will be discussed, with emphasis on network analysis and optimization, adjustment procedures and methods, models in geodesy and gravimetry, and computational problems in modern observation techniques, among other topics. Five different postsymposium tours to places of interest in the Katowice area will be offered to symposium participants on June 22 and 23.

Mine Water

September 17–21, 1985 Second International Mine Water Congress, Granada, Spain. Sponsor: International Mine Water Association. (R. Fernandez Rubio, School of Mines, Technical Univ. of Madrid, Rios Rosas 21, Madrid 3, Spain or Roy E. Williams, Department of Geology, Univ. of Idaho, Moscow, ID 83843; tel.: 208-885-6259.)

The deadline for the submission of abstracts is December 31, 1984.

Suitable subjects for papers include mine hydrology, tailings disposal, contamination due to mineral resource waste, and mathematical models and field studies of these topics.

Meeting Report

Satellites Over Antarctica

Observations of the polar regions from space have led to significant contributions in a variety of scientific disciplines: geophysics, geodesy, geology, glaciology, meteorology, climate, oceanography, biology, and the physics of the upper atmosphere, ionosphere, and magnetosphere. Some results in these diverse fields were described in papers presented at the recent joint COSPAR (Committee on Space Research) and SCAR (Scientific Committee on Antarctic Research) Workshop on Satellite Observations of the Antarctic: Past, Present, and Future. Other results were presented at the COSPAR Symposia on Space Observations for Climate Studies and on Achievements of the International Magnetospheric Study. Each of these meetings was held during the 25th Plenary meeting of COSPAR, which took place in Graz, Austria, from June 25 to July 7, 1984.

In general, instruments aboard polar-orbiting satellites have measured properties of the earth's upper atmosphere and plasma environment in situ. Other instruments look down and "remotely sense" characteristics of the atmosphere and the earth's surface. Such observations, which complement observations made from the ground, have advanced our understanding of the earth's environment considerably.

Since 1972, five Landsat satellites have viewed cloud-free areas of the earth's surface from a height of about 900 km. Observations of 185-km² regions are made in two spectral bands in the visible region of the spectrum and also in two near-infrared bands. The Landsat data may be used to prepare black and white pictures, which are used for making accurate maps. Surface features as small as 100 m were revealed in the early Landsat images, and features as small as 30 m were seen in the more recent data. Alternatively, the data can be processed digitally, to produce better maps with scales of 1:1,000,000 or 1:250,000, and subjected to computer enhancement techniques. Information in the different spectral bands can be combined digitally to produce false color images, which reveal features that cannot otherwise be seen; for example, the geology of rocky outcrops in the Antarctic can be studied. Also, the "blue ice" areas, where ice flow and surface ablation bring meteorites to the surface, can be located. At low angles of solar illumination the shadows on the images highlight glaciological features. The images are especially useful for defining the position of the coastal ice margins and icebergs in the ocean. Some ice margins in the Antarctic peninsula are known to be retreating by up to 100 m yr^{-1}, which could be a response to changes in global climate.

Microwave observations taken from satellites are unaffected by clouds and darkness during the polar winter. Significant advances in sea ice science and in ice mapping for operations in the polar seas have resulted from the passive microwave imaging data collected by the Nimbus satellites since December 1972. The microwave data are used by the U.S. Navy, along with other satellite data, to prepare weekly sea ice maps, which are distributed to interested groups internationally. The Weddell polynya, an occasional major oceanographic anomaly within the winter ice pack, was discovered in the passive microwave data of 1974. Quantitative determinations of the total area of open water within the ice pack showed more open water than was suspected before the satellite microwave observations. The greater heat flux to the atmosphere and the new ice production in the observed open water are important factors in studies of the atmospheric and oceanic dynamics of the Antarctic region.

Studies of the 12-year satellite record of sea ice extent have shown substantial interannual variability and regional sea ice changes that have been related to changes in atmospheric circulation, but no long-term trend in the ice cover has been detected. Monitoring of the ice cover with passive microwave sensors and the systematic analysis of acquired data should be continued indefinitely because of both their operational utility and their scientific importance to several fields of research. The distribution of biological organisms, for example, and the circulation of the ocean are strongly influenced by the distribution and seasonal cycle of the sea ice cover.

Satellite-borne radar altimeters have much potential for ocean, climate, and glaciological research. Precise altimeters can observe large-scale oceanic currents, waves, ocean swell, sea ice boundaries, icebergs, surface elevation of the ice sheets, and ice shelf frontal positions. Although previous radar altimeters have only provided coverage to 72°S, and the most precise altimetric mission planned (TOPEX) will only go to 63.4°S, the radar altimeters on the European ERS 1 and the U.S. Navy N-Ross will provide data to about 81.5°S. Scientific

Meetings (cont. on p. 1190)

Groundwater Contaminant Transport Modeling. The course, to be held January 29-31, 1985, at Princeton University, Princeton, N. J., aims to provide geohydrologists, engineers, and professionals in related disciplines with the background in geology, groundwater hydrology, and numerical methods necessary to use and understand groundwater transport models. This course is designed for individuals involved in the development, application, or evaluation of groundwater models describing contaminant flow; participants should have a rudimentary understanding of partial differential equations and familiarity with FORTRAN computing.

The short course fee is $495 (U.S.). This covers the text, $50 in computer time, computer code and documentation, and cocktail hour. Inquiries should be directed to C. F. Pinder, Department of Civil Engineering, Princeton Univ., Princeton, NJ 08544 (tel.: 609-452-4602). Please note that enrollment is limited. All proceeds from this course will be used for graduate student research support.

POSITIONS WANTED

Physical Oceanographer. M.S. 1983. Experience in hydrographic data acquisition and analysis in the SW Atlantic and NE Pacific. Seeking a position as research assistant in academic institution, industry or government. RMO, 2855 Three Mile Lane, McMinnville, OR 97128.

STUDENT OPPORTUNITIES

Graduate Teaching and Research Assistantship in Marine Environmental Sciences and Coastal Oceanography. Opportunities for graduate study with graduate and research assistantships available for students interested in MS and PhD degree programs in marine environmental sciences and coastal oceanography. Awards cover tuition and academic year stipend up to $7,883. Additional summer support also available up to $3,000. Write: Graduate Programs Chairman, Marine Sciences Research Center, SUNY Stony Brook, Stony Brook, NY 11794.

SERVICES, SUPPLIES, COURSES, AND ANNOUNCEMENTS

Availability of Request for Cooperative Agreement Applications RFA# 1008-A. Acid Deposition Monitoring Support for Effects Research/U.S. Environmental Protection Agency. Application Receipt Date: January 18, 1985.

The U.S. Environmental Protection Agency (E.P.A.), under the National Acid Precipitation Assessment Program (NAPAP), is announcing the availability of funds for fiscal year 1985 for awarding a cooperative agreement(s) to support acid deposition monitoring stations to enhance the results of acid deposition effects studies. The research topics of primary interest involve studies of acid deposition (including ambient air pollution) mechanisms and rates of damage to forest ecosystems, calibrated watersheds and building materials. EPA has approximately one million dollars available to award cooperative agreement(s) to support this project. Support for this program may be for a period extending up to five years. In order to receive a copy of the RFA and further information contact:

Dr. Clarke E. Gaylord
Research Grants Staff
Office of Research & Development
U.S. Environmental Protection Agency
401 M Street, SW
Washington, D.C. 20460
Telephone 202-382-7475.

Request for Preproposals. The U.S. Environmental Protection Agency, Environmental Research Laboratory, Corvallis, is seeking PREPROPOSALS for interdisciplinary research on terrestrial processes which contribute to, or mitigate, surface water acidification. The intent of this research is to develop integrated biogeochemical process studies at sites representative of areas sensitive to acidification, with the ultimate objective of characterizing geochemical, biological, and hydrologic processes (and their interactions) which control regional surface water response to acidic deposition. Research must be focused on watershed, plot, or greenhouse/laboratory scale projects; integrated process studies are strongly encouraged.

Written requests for information on proposal submission must be received by December 7, 1984, and should be forwarded to Dr. Raymond G. Wilhour, Chief, Air Pollution Effects Branch, USEPA, 200 S.W. 35th Street, Corvallis, Oregon 97333.

Meetings (cont. from p. 1189)

studies with these satellites should include examination of the variability of the Antarctic circumpolar current, interactions between ocean waves and sea ice at the ice edge, and changes in the ice sheet/ice shelf margins. Ultimately, a laser altimeter may be required on future satellites to determine whether the ice sheet is growing or shrinking. Detection of changes in surface elevation by satellite altimetry is the only way to measure changes in ice volume. For these altimeter studies the orbit of the satellite must be known precisely, and satellite tracking in the Antarctic contributes data needed for this purpose.

Synthetic Aperture Radar devices on polar orbiting satellites can give images of the ocean surface that are valuable for determining wave properties and sea ice type and motion and for the routing and navigation of ships. Also, radar imagery would be extremely useful for mapping the land ice in a similar manner to that done with Landsat data but without the impediment of cloud cover. Although satellite radar imagery has not yet been used in the Antarctic, future satellite missions planned by several countries should provide this capability if a suitable readout station in the Antarctic, an adequate on-board recording facility, or a satellite data relay is provided.

Satellites have aided glaciological research in another way. The radio signals from polar-orbiting navigation satellites such as Transit and the new Global Positioning System, recorded at several sites on a moving ice sheet, give not only the velocity of the ice flow but also the strain or deformation of the ice. Such data are needed for modeling and understanding the ice flow dynamics.

The Magsat satellite measured the earth's magnetic field accurately in 1979. The data have been used to locate magnetic anomalies on the earth's surface and hence to identify the boundaries between tectonic plates and other prominent geologic structures. A Geopotential Research Mission (GRM) carrying extremely sensitive accelerometers or other sensors to investigate anomalies of the earth's gravitational field as well as the magnetic field is now being considered. Determination of the geoid in the Antarctic region is of interest for studies of the earth's structure and the calculation of precise satellite orbits for altimetric measurements.

In meteorological and radiation budget studies, satellite observations can contribute significantly to the World Climate Research Program in two distinctly different ways. First, meteorological data can be automatically collected and transmitted in near real time from remote regions of the world to weather analysis and forecasting centers via the French ARGOS System or via satellites in geostationary orbit. Second, the dynamics of the atmosphere and the earth's radiation balance can be investigated. For example, the genesis and motion of major storms can be studied by examining sequential images of developing cloud systems in different spectral bands. The amount of infrared radiation coming from the earth and its atmosphere has been well studied from space by using radiation sensors. The emitted radiation is analyzed to give information on the distribution (height, latitude, and longitude) of trace atmospheric species, such as ozone, and the oxides of nitrogen and methane. Satellite observations of the atmosphere, oceans, and cryosphere from space are contributing vital new information on the many complex feedback processes involved in determining the world's climate.

Analysis of the color of the ocean surface, as measured from the Nimbus 7 satellite, has revealed variable concentrations of chlorophyll in the ocean, and thus variable concentrations of phytoplankton. The color data show ocean eddies and other flow patterns, such as meanderings of the circumpolar current. Not only is such information useful in studying ocean dynamics, but it can also be used to locate concentrations of fish suitable for harvest and, in the southern ocean, regions containing phytoplankton-feeding krill. Since this information on the biological productivity of the oceans is essential to manage the ocean's living resources properly, it is highly desirable that an ocean color scanner be placed aboard another polar-orbiting satellite in the near future.

The tenuous uppermost atmosphere, at heights above 100 km, can best be studied by using observations made from space combined with those from the ground. The aurora australis and aurora borealis observed in the polar regions provide spectacular visible displays of the effect of energetic solar events on the earth's environment. After a solar flare, energetic charged particles and high-speed streams of solar wind disturb the earth's magnetosphere, which is the comet-shaped region of geomagnetic field lines surrounding the earth. Motions of electrically charged particles are generated in the ionosphere at the base of geomagnetic field lines extending from the distant regions of the magnetosphere. These ionic motions drag along the neutral atmosphere at speeds of several hundred meters per second. Because in the Antarctic the magnetic pole is twice as far from the geographic pole as it is in the Arctic, effects of the ion motions on the neutral atmosphere are observed to be more dramatic than in the northern hemisphere. Consequently, the effects are more evident, readily studied, and understood in the south than in the north. This has practical consequences because after increased solar activity the disturbed ionosphere in polar regions adversely affects radio communications. Furthermore, enhanced geomagnetic activity during solar-terrestrial events interferes with aeromagnetic surveys being conducted for hydrocarbon and mineral exploration.

For the future, there is great potential for extending these significant scientific achievements based on satellite observations, especially if space-borne and ground-based projects are planned as parts of international programs of polar research. New technology is now available for studying the earth's land, ocean, and ice surfaces and the atmosphere from ground level out to the interplanetary medium. The potential and results of the new technology for interdisciplinary studies of the polar regions has been described in the COSPAR meetings and in other scientific reports. Global climate, for example, is particularly sensitive to processes operating in the polar regions and much-needed Antarctic climate research is planned within the World Climate Research Program. The upper atmosphere at high latitudes, where energy from the solar wind and the magnetosphere is deposited, will be studied as part of the International Solar-Terrestrial Physics program proposed for the 1990's.

During the latter part of this decade, several remote sensing missions are planned in different countries. The space shuttle launched from Vandenberg Air Force Base in California can also carry in situ observing and remote sensing instruments into the all-important polar orbit. In the next decade the Polar Platform component of the U.S./International Space Station program will be able to carry large instruments of advanced design into polar orbit for multidisciplinary studies. Systems will be needed to transfer the large amounts of space data to computers for detailed analysis and interpretation by scientists in several countries. In the meantime, data already obtained should be made widely available, and the resources and techniques necessary for their processing, full analysis, and interpretation should be dedicated. The keys that are needed to unlock many significant scientific problems that are of global concern and importance are to be found in the earth's polar regions.

This report was contributed by M. J. Rycroft, *of the British Antarctic Survey, Cambridge, U.K., and* J. J. Zwally, *of NASA Goddard Space Flight Center, Greenbelt, MD; they were the coconveners of the Symposium on Satellite Observations of the Antarctic: Past, Present, and Future.*

AGU

Geophysics Films

The Education and Human Resources Committee is planning to compile a listing of films (including videotapes) of interest to geophysicists. This list will be available to individuals and institutions and will include information such as film title, length, cost of rental, and address of source. If you know of any such listings of films, or have any suggestions as to a source, please contact the committee, via AGU: Education and Human Resources Committee, AGU, 2000 Florida Ave., N.W., Washington, DC 20009.

This item was contributed by Constance Sancetta, *Lamont-Doherty Geological Observatory of Columbia University, Palisades, N. Y.*

VGP Awards

Robert C. Newton of the University of Chicago and Michael J. O'Hara of the University College of Wales, U.K., have been named the recipients of VGP awards for 1984. Newton is cited for his contributions to studies of high-pressure phase equilibria and O'Hara for his contributions to the petrogenesis of lunar and terrestrial basalts. O'Hara will be presented with the award at the VGP/Planetology luncheon on Tuesday, December 4, at the AGU Fall Meeting in San Francisco. Presentation of Newton's award is scheduled for the 1985 AGU Spring Meeting in Baltimore.

Fall Meeting Child Care Services

AGU has the names and addresses of two temporary child care services in San Francisco recommended by the Convention and Visitors Bureau. Call Meetings and Member Programs Division for details.

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Electromagnetics

0773 Electromagnetics (Remote Sensing)
AIRBORNE MICROWAVE MEASUREMENTS OF THE SOUTHERN GREENLAND ICE SHEET
C. T. Swift (Electrical & Computer Engineering Department, University of Massachusetts, Amherst, MA, 01003), P. S. Hayes, J. S. Herd, W. L. Jones, and V. E. Delnoro

Microwave remote sensing measurements were collected over Greenland with the NASA C-130 aircraft used as a platform. The principal instruments were a C-Band radiometer and an X-Band scatterometer which simultaneously collected both active and passive microwave remote sensing data. The results indicate that subsurface inhomogeneities control the scattering and emission process, including anisotropic effects. The results strongly suggest that microwave remote sensing techniques can provide a relative measure of the density and orientation of the volume scatters.

J. Geophys. Res., B, Paper 4B1308.

0785 Tropospheric Propagation
MUTUAL COHERENCE FUNCTION FOR LINE-OF-SIGHT MICROWAVE PROPAGATION THROUGH ATMOSPHERIC TURBULENCE
S.F. Clifford (National Oceanic and Atmospheric Administration, Environmental Research Laboratories, Wave Propagation Laboratory, 325 Broadway, Boulder, Colorado, 80303) and R.J. Lataitis.

Existing expressions for the line-of-sight plane and spherical wave mutual coherence function (MCF) are subject to the restriction that the wavelength λ be much smaller than the inner scale of turbulence [illegible]. It is shown that this restriction can be replaced by [illegible], where [illegible] is the wave coherence length. For weak, path-integrated turbulence, [illegible], indicating that existing expressions for the MCF are valid for wavelengths well into the microwave range. (Propagation, atmospheric turbulence.)

Rad. Sci., Paper 4S1332.

Exploration Geophysics

0920 Magnetic and electrical methods
EVALUATION OF ANISOTROPY BY SHEAR-WAVE SPLITTING
Stuart Crampin (British Geological Survey, Murchison House, West Mains Road, Edinburgh EH9-3LA, Scotland UK)

The polarizations of three-component shear wavetrains carry unique information about the internal structure of the rock through which they pass: specifically, commonly observed shear-wave splitting may contain information about the orientation of crack distributions. This information cannot usually be recovered from shear waves recorded at the free surface because of interference with the interaction of the shear wave with the surface, even for nearly vertical incidence. However, shear-wave splitting in synthetic three-component vertical seismic profiles, in some cases, may be interpreted directly in terms of the direction of strike of vertical cracks. Because the human eye is not skilled at identifying the phase relationships between three-component seismograms played out conventionally as parallel timeseries, the polarizations are displayed in orthogonal sections of the particle displacements to facilitate recognition and evaluation of the shear-wave splitting. Estimating the orientations of cracks, and hence of preferred directions of flow, by seismic investigations could be of crucial importance to production and reservoir engineering.
GEOPHYSICS, VOL. 50, NO. 1

0930 Seismic methods
GEOPHONE FREQUENCY CALIBRATION AND LASER VERIFICATION
A. MacArthur (Boeing Aerospace Company, P.O. Box 3999, MS 8C-23, Seattle, WA 98124)

A geophone frequency calibration procedure has been developed that provides both amplitude and phase information over a selectable frequency range with a single measurement. It is easy to perform in either a field or laboratory environment using a two-channel analog input spectrum analyzer, and an inexpensive, easily constructed, shaker table. A second calibration procedure that uses laser interferometry was also developed and implemented to verify the first, more practical method. Agreement between the two procedures is within the uncertainty limits of the test equipment at all frequencies including those near and at physical resonance. Some concepts of digital signal processing were reviewed that affect the interpretation of both calibration and seismic test data.
GEOPHYSICS, VOL. 50, NO. 1

Geophysical Research Letters

Volume 11 Number 11 November 1984

Geochemistry

1410 Chemistry of the atmosphere
INFLUENCE OF TEMPERATURE, MOISTURE AND ORGANIC CARBON ON THE FLUX OF H_2 AND CO BETWEEN SOIL AND ATMOSPHERE: FIELD STUDIES IN SUBTROPICAL REGIONS
R. Conrad and W. Seiler (Max Planck Institut für Chemie, Saarstrasse 23, D-6500 Mainz, Fed. Rep. Germany)

Production and deposition rates of atmospheric hydrogen and carbon monoxide were studied during field measurements in subtropical regions, i.e. Transvaal (South Africa), Andalusia (Spain) and the Karoo (South Africa). Measurements were carried out by applying static and equilibrium box techniques. The equilibrium technique has been introduced as a novel method to measure production and destruction rates simultaneously even when soil conditions (e.g. temperature) change during the course of the measurements. Deposition velocities of H_2 and CO were virtually independent of the soil temperature measured in 3-10 mm depths and agreed with those measured in the temperate regions. The deposition velocities were inhibited or stimulated by irrigation water depending on the conditions of the individual field sites. H_2 production by soil was not observed. By contrast, CO was produced by soil in a dark chemical reaction. Production rates increased exponentially with soil temperatures giving activation energies of 57-110 kJ mol^{-1} and increased linearly with soil organic carbon content. CO production rates followed a diel rhythm parallel to soil surface temperatures. Production generally exceeded CO deposition during the hot hours of the day so that arid subtropical soils act as a net source of atmospheric CO during this time. On a global basis, CO production by soil may reach source strengths of 10 Tg yr^{-1} which is considerably less than the global deposition of CO estimated to be 190-580 Tg yr^{-1}. Global H_2 deposition rates were estimated to 70-110 Tg yr^{-1}.

J. Geophys. Res., D, Paper 4D1362

1410 Geochemistry (Chemistry of the Atmosphere)
AIR-TO-SEA FLUXES OF LIPIDS AT ENEWETAK ATOLL
O. C. Zafiriou (Department of Chemistry, Woods Hole Oceanographic Institution, Woods Hole, MA 02543), R. B. Gagosian, E. T. Peltzer, J. B. Alford and T. Loder

Data from the SEAREX program 1979 rainy season are reported, including concentrations of n-alkanes, n-alkanols, sterols, n-alkanoic acids and their salts, and total organic carbon to rain. All the higher molecular weight biomarker compounds are of terrestrial origin. The wet and dry fluxes and gas/particle partitioning of these materials are estimated. Annual fluxes are estimated from the limited data set using a ^{210}Pb/organic compound correlation. The gas/particle speciation of microcrystalline plant waxy materials is estimated under the supposed conditions of transport, < 700 mb, < 0°C. No strong marine inputs were found. (Long-range transport, lipids, aerosols, fluxes).

J. Geophys. Res., D, Paper 4D1293

1430 Chemistry of meteorites and tektites
CRYSTAL CHEMISTRY OF METEORITIC HIBONITES
R. G. Burns and V. M. Burns (Department of Earth, Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology Cambridge, Massachusetts 02139)

Structural features influencing relative enrichments, cation stabilities, and colors of vanadium-, titanium-, and iron-bearing hibonites ($CaAl_{12}O_{19}$) in meteorites are examined. These transition elements may substitute for Al^{3+} ions which occur in five different coordination sites in the hibonite crystal structure, including three distinct octahedra [Al(1), Al(3), and Al(4) positions], one tetrahedron [Al(2) position], and an unusual trigonal bipyramid [the Al(5) position] providing five-fold coordination by oxygen ions. Mossbauer spectral measurements of terrestrial and synthetic iron-bearing hibonites demonstrate that although Fe cations occur in four-, five-, and six-fold coordinations, they are relatively enriched in the trigonal bipyramidal Al(5) site which provides the largest average Al^{3+}-oxygen distance. Similarities with Mossbauer spectra of blue sapphires indicate that some Fe^{2+} ions are also located adjacent to Ti^{4+} cations in hibonite's face-sharing Al(3) octahedra.

Arguments based on ionic radius and crystal field stabilization energy criteria are used to explain the enrichment of Fe^{2+} ions in the five-fold coordination Al(5) site of hibonite. Similar electronic stabilities apply also to V^{3+} and Ti^{3+}, but not to Cr^{3+}, providing an explanation for the fractionation of vanadium into meteoritic hibonites. Three mechanisms are proposed for the blue colors of these hibonites, the visible-region spectra of which show minima at 550 nm (blue) between two absorption bands at about 400 nm and 700 nm. One assignment of these bands is to crystal field transitions within V^{3+} and Ti^{3+}, respectively, which are located in the symmetry D_{3h} trigonal bipyramidal Al(5) site. A second assignment of the 700 nm band is to an intense Fe^{2+},Ti^{4+} intervalence transition between traces of these cations located in adjacent face-shared Al(3) octahedra. The orange color and disappearance of the 700 nm produced by the heat treatment of hibonite at elevated oxygen fugacities may then be the result of oxidation of either Ti^{3+} to Ti^{4+} or Fe^{2+} to Fe^{3+}. A third explanation of the blue-orange color change involves color centers induced when primordial ^{26}Al decays to ^{26}Mg, or from trapped electrons in the lattice as a result of non-stoichiometry and structural defects in hibonite. (hibonite, refractory phases)

J. Geophys. Res., B, Paper 4B5813

1499 General (Chemistry of the moon)
NOBLE GAS COMPONENT ORGANIZATION IN APOLLO 14 BRECCIA 14318: ^{129}I AND ^{244}Pu REGOLITH CHRONOLOGY
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Noble gas, petrological and chemical studies of grain-size separates from lunar regolith breccia 14318 demonstrate that the noble gases are organized into two functional components, volume-correlated and surface-correlated. As in regolith breccia 14301, volume-correlated xenon in 14318 is primarily spallation-derived and the surface-correlated component contains not only solar wind xenon but also significant amounts of "parentless" xenon from the fission of now extinct ^{244}Pu and the decay of now extinct ^{129}I. The ratio $^{129}Xe/^{136}Xe$ in the total surface-correlated parentless component, as identified in grain-size analysis, is substantially higher than in the least tightly bound parentless component identified in stepwise heating analyses, confirming the trend seen in 14301. If the order of release of gases in stepwise heating is related to the order of incorporation in the simplest way (first in, last out), incorporation of these grain-surface components was probably time-ordered. This trend, and the continuous variation in this ratio, suggest that the $^{129}Xe/^{136}Xe$ ratio in each identifiable parentless component is characteristic of the xenon being produced at the particular time of acquisition. Such observations provide the basis for a new chronometer from which we conclude that acquisition of parentless xenon was an ongoing process spanning at least 90 m.y., beginning no more than 44 ± 34 m.y. after the formation of the most meteorites and possibly predating xenon acquisition for the earth. (Parentless fission xenon, lunar chronology, lunar regolith).

J. Geophys. Res., B, Paper 4B5844

Geodesy and Gravity

1920 Geometric observations and methods
ON-BOTTOM GRAVITY PROFILE ACROSS THE EAST PACIFIC RISE CREST AT 21° NORTH
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Twenty-one on-bottom gravity stations were taken with a LaCoste-Romberg model G gravity meter inside the submersible *Alvin*, over a 6 km long cross-strike profile which straddles the East Pacific Rise spreading center at 21°N. The residual Bouguer anomaly shows a 1.5 mGal low with a total half-width of 1.7 km centered about the spreading axis and hydrothermal vents. Uncertainties in the ocean depth are believed to contribute a standard error of about 0.3 to 0.4 mGal for the gravity data. The observed elevation factor of 0.1552 mGal/m indicates that the upper ocean crust bulk density is 2.62 is 2.62 ± 0.09 g/cm³. On the other hand, 90 rock samples give a density of 2.90 ± 0.01 g/cm³. This suggests that the large-scale porosity of the upper crust is 14 percent. The gravity anomaly was inverted to find the ideal body with the smallest maximum density contrast which satisfies the data and their associated errors. This body extends from the sea floor to 2 500 m depth and has a density contrast of −0.043 g/cm³. If the density contrast is allowed to be as large as −0.1 g/cm³, the top of the ideal body can be as deep as 300 m and its bottom as deep as 1 300 m; alternatively with the body top at the sea floor, the bottom of the body can be no shallower than 500 m. The ideal body is, therefore, restricted to the dikes and flows of the upper ocean crust. The body is not thought to represent magma in the shallow crust, but rather fractured crust filled with heated seawater.
GEOPHYSICS, VOL. 49, NO. 12

1940 Polar Wobble
EXCITATION STUDY OF THE LAGEOS DERIVED CHANDLER WOBBLE
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We have used the University of Texas LAGEOS series of pole positions to obtain a Chandler wobble data set that has then been deconvolved. The deconvolution filter used here can be derived from the ideas of Backus-Gilbert inverse theory. By trading-off resolution against accuracy a model for the Chandler wobble's excitation function can be obtained that is able to reproduce all of the features of the input Chandler wobble data set except for the noise contained therein. Two observed features of this excitation function are discussed. First, a change of amplitude 0".04 in the direction −54°E longitude is observed to have taken place from August 14.0, 1977 to September 4.0, 1977. The only notable geophysical event known to us to have occurred in this time interval is the great Sumba, Indonesia earthquake of August 19, 1977. However, elastic dislocation theory applied to a double-couple model of this event is unable to explain the observed pole shift. We speculate that if the observed shift is causally related to the Sumba event it could be due to motions of the subducted slab occurring within 20 days of the main shock. By deconvolving Chandler wobble data sets obtained by other independent methods, we find that this shift is not evident in the excitation function derived from BIH data. Therefore, we cannot conclusively determine whether or not the shift seen in the LAGEOS-derived excitation function is geophysically significant. Secondly, a study is conducted into the possible influence on the Chandler wobble of the extraordinarily strong 1982-1983 Southern Oscillation/El Nino event which has been observed to have had a great influence on the length of day. We find in the Chandler wobble's excitation function a very encouraging signature that can be explained by the 1982-1983 El Nino event. It is encouraging in the sense that the y-component $\Psi_y(t)$ of the excitation function appears to be temporally correlated with the Southern Oscillation Index and that the polarity and overall magnitude of the change in Ψ_y, as well as the quiescence of the excitation function's x-component during this period are all consistent with observations of the 1982-1983 El Nino. (Chandler wobble, deconvolution, El Nino, earthquakes).

J. Geophys. Res., B, Paper 4B5032

Geomagnetism and Paleomagnetism

2530 Spatial variations
A REVIEW OF PROBLEMS AND PROGRESS IN STUDIES OF SATELLITE MAGNETIC ANOMALIES
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The incomplete removal of time-varying effects in the Magsat data leads to the necessity of fitting low-order polynomial functions in order to minimize differences between passes. This process makes the estimation of the zero-level in the crustal anomaly field very difficult. Refinements in main field analysis, ring-current estimation, and the identification of other time-varying field sources should provide us with a physical realization of these differences. The spectral overlap of core and crustal anomaly fields makes it particularly difficult to interpret the longer wavelengths of crustal anomalies. Equivalent source techniques for the inversion of the satellite data to a constant-thickness, varying-magnetization source layer solution are well developed. Magnetization and reduced-to-the-pole anomaly maps are now available for many regions. Problems of instability of mathematical inversions are still present and are particularly noticeable near the magnetic equator. There is now sufficient information on the Curie points and magnetic properties of rocks which have been derived from the deep crust and upper mantle to begin to develop magnetization-depth models for a number of tectonic environments. While the familiar Fe-Ti oxides are the magnetic minerals characteristic of the crust, relatively non-magnetic chromium spinels and magnesian ilmenites are characteristic of the sub-continental mantle; thus the Moho is the magnetic bottom of the continents except where the Curie isotherm is elevated within the crust. Intensity of magnetization in the continental crust is strongly dependent on metamorphic grade, and in general increases with basicity: mafic granulites tend to form the most magnetic laterally extensive zones of the crust. Some large-scale mafic plutonic complexes also have very large magnetizations. Model studies and laboratory measurements are in agreement that the more magnetic rocks of the crust typically have magnetization values in the range 3-6 A/m. In the deep crust Curie points are predominantly near that of magnetite, although in hot, anhydrous environments in active tectonic zones Curie temperatures may be reduced below 300°C. A comprehensive laboratory program to further characterize the magnetic properties of all lithologies important in the crust is in progress, and much work remains. The goal is an understanding of how crustal evolutionary processes have left their imprint in the magnetic mineralogies, and how this in turn is reflected in the anomaly field.

J. Geophys. Res., B, Paper 4B1264

2530 Spatial variations (all harmonics and anomalies)
MAGSAT SCALAR MAGNETIC ANOMALIES AT NORTHERN HIGH LATITUDES
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A new scalar magnetic anomaly map derived from Magsat data at high northern latitudes shows important correlations with major geologic and tectonic features. Positive magnetic anomalies over some high-grade metamorphic Precambrian terranes contrast with negative anomalies over lower grade Precambrian terranes. A positive anomaly is associated with the Aleutian Arc-Trench system, a region of active plate convergence. Negative anomaly fields are associated with the Nansen-Gakkel Ridge, a region of plate accretion in the Arctic Basin, with its extension into the seismically active Cherskiy Mountains in eastern Siberia, and with the Labrador Sea, an extinct spreading centre. However, a positive anomaly occurs over Iceland, on the mid-Atlantic spreading ridge system, and an intense positive anomaly occurs over the Alpha Ridge in the Arctic Basin. The relations among the Magsat orbit, the rotation of the earth, and the movements of the auroral oval have major effects on the spatial distribution of acceptable data and, therefore, on map resolution. (Magnetic anomalies, crustal, satellite, auroral oval).

J. Geophys. Res., B, Paper 4B0879

2540 Spatial variations
CURIE ISOTHERM SURFACES INFERRED FROM HIGH-ALTITUDE MAGNETIC ANOMALY DATA
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Traditional methods of Curie depth estimation involving spectral analysis of low-level aeromagnetic data require that depth to the bottom of a magnetic crustal layer be large relative to depth to top, so that spectral separation can be achieved. An alternate method for high-altitude data, where depth to magnetic layer top and bottom are virtually indistinguishable, is described. Apparent magnetization variation in a thin equivalent layer is obtained by inversion of the anomaly data. The information in such a model is essentially the vertical integral of magnetization in the real layer to some resolution limit, and within some ambiguity in level. This can be transformed to a model of thickness variation in a layer of constant magnetization, given some minimal constraints. The thickness variations may reflect Curie isotherm undulations in regions of high crustal heat flow; Curie depth models then provide a constraint on crustal thermal models. The method was first applied to a magnetization model for the western U.S. derived from Magsat data. A Curie surface model was obtained, and used to constrain simple thermal models along two crustal sections. Associated surface heat flow is in agreement with observations. The method was then applied to upward continued aircraft data from the Oregon Cascades. Results are in reasonably good agreement with previous results based on spectral analysis and with measured heat flow.

J. Geophys. Res., B, Paper 4B1228

2560 Time Variations, Paleomagnetism
LATE QUATERNARY PALEOMAGNETIC FIELD SECULAR VARIATION FROM TWO MINNESOTA LAKES
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Detailed paleomagnetic records from the wet sediments of two Minnesota lakes are the basis for estimating the local secular variation of the earth's magnetic field during late Quaternary time. Results from Lake St. Croix cover the interval 0-9500 years B.P., and results from Kylen Lake cover the interval 4000-14,000 years B.P. Paleomagnetic data were recovered from two replicate cores in each lake by sampling the sediments at 3- to 10-cm intervals. Analysis of the potential errors in the results indicates that all cores were correctly oriented in the vertical plane but that some azimuthal offsets of individual core segments did occur. Various methods for correcting the occasional azimuthal offsets are described. The final paleomagnetic data sets from each lake show a high degree of internal consistency. These results also show close correspondence (1) between the two lakes, (2) with the known historic magnetic field variation, and (3) with paleomagnetic results from dated archeological material and lava flows from the western United States. Rock-magnetic analysis of the lake sediments indicates that the natural remanent magnetization is the result of a physical remanence acquisition process (detrital remanent magnetization) active at or near the sediment/water interface. There is no evidence for a systematic inclination error in the results. Statistical analysis of vector time series determined from the paleomagnetic data indicates that both the field-vector and virtual geomagnetic pole (VGP) distrib-utions are non-Fisherian and essentially axial-dipolar when averaged over 10,000 years. Spectral analysis of the scalar inclination and declination suggests that the field behavior is separable into a dominant low-frequency dipolelike waveform (period of ~9500 years) and a higher-frequency band irregular waveform ("fundamental" period of ~2400 years with multiples at 1200, 800, and 600 years) that may represent the nondipole field. This irregular waveform is interpreted as resulting from zonal drift of the nondipole field past Minnesota on the basis of waveform morphology and VGP circularity. Zonal drift of the nondipole field plus a low-frequency dipole variation can account for almost all of the observed paleomagnetic field variation. (Paleomagnetism, secular variation).

J. Geophys. Res., B, Paper 3B1738

Hydrology

3130 Hydrology (Groundwater)
STOCHASTIC MODELING OF GROUNDWATER FLOW BY UNCONDITIONAL AND CONDITIONAL PROBABILITIES: THE INVERSE PROBLEM
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The inverse problem consists in determining the transmissivity at various points, given the shape and boundary of the aquifer and recharge intensity and given a set of measured logtransmissivity Y and head H values at a few points. The logtransmissivity distribution is regarded as a realization of a random function of normal and stationary unconditional probability density distribution. The solution of the inverse problem is the conditional normal p.d.f. of Y, conditioned on measured H and Y, which is expressed in terms of the unconditional joint p.d.f. of Y and H by Bayes formula. The problem is reduced to determining the unconditional head-logtransmissivity covariance and head variogram for a selected Y covariance which depends on a few unknown parameters. This is achieved by solving a first-order approximation of the flow equations.

The method is illustrated for an exponential Y covariance and the effect of head and transmissivity measurements upon the reduction of uncertainty of Y is investigated systematically. It is shown that measurement of H has a lesser impact than those of Y, but a judicious combination may lead to significant reduction of the interval of confidence of Y. Possible applications to real aquifers are outlined.

Water Resour. Res., Paper 4W1287

3160 Runoff and Streamflow
ALGORITHMS FOR OPTIMIZING HYDROPOWER SYSTEM OPERATION
J. C. Grygier and J. R. Stedinger (Department of Environmental Engineering, Cornell University, Ithaca, New York 14853)

Successive linear programming, an optimal control algorithm, and a combination of linear programming and dynamic programming (LP-DP) are employed to optimize the operation of multireservoir hydrosystems given a deterministic inflow forecast. The algorithms maximize the value of energy produced at on-peak and off-peak rates, plus the estimated value of water remaining in storage at the end of the 12-month planning period. The LP-DP algorithm is clearly dominated. It takes longer to find a solution and produces significantly less hydropower than the other two procedures. Successive linear programming (SLP) appears to find the global maximum and is easily implemented. For simpler systems, the optimal control algorithm finds the optimum in about one fifth the time required by SLP but is harder to implement. Computing costs for a two-reservoir, twelve-month deterministic problem averaged about seven cents per run using optimal control and thirty-seven cents using successive linear programming. (Reservoir operation, optimization).

Water Resour. Res., Paper 4W1117.

3175 Soil moisture
INFILTRATION IN SWELLING SOILS
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Infiltration phenomena in swelling soils were investigated theoretically. The approach taken consisted of applying both the approximate analytical techniques developed by Parlange and coworkers and conventional finite-difference numerical methods to study the generalized Richards equation for one-dimensional infiltration in a swelling soil. Equations were derived for the ponding time and the post-ponding infiltration rate are generalizations of the Parlange-Smith model expressions for rigid soils. Ponding times for swelling soils were shown to be shorter than those for nonswelling analogs, and post-ponding infiltration rates in swelling soils were shown to approach zero instead of becoming equal to the hydraulic conductivity, as in rigid soils. These results were confirmed, both qualitatively and quantitatively, with the numerical model, which also provided instantaneous moisture profiles and surface swelling predictions in agreement with field observations. A three-parameter infiltration equation proposed recently by Parlange, Lisle, Braddock, and Smith was generalized to describe swelling soils and shown to be in good agreement with published laboratory and field data. It appears that the generalized analytical model equations developed can be employed conveniently in hydrologic applications which do not require high accuracy in predictions.

Water Resour. Res., Paper 4W1236.

Meteorology

3735 Electrical phenomena
COMPUTED RESPONSE OF THE SPACE CHARGE LAYER CREATED BY CORONA AT GROUND LEVEL TO EXTERNAL ELECTRIC FIELD VARIATIONS BENEATH A THUNDERCLOUD
S. Chauzy (Université Paul Sabatier, Toulouse, France), C. Rennela

The present numerical simulation deals with ion creation by corona at ground level and their evolution between the ground and the thundercloud. The study starts from a previous model in which the external electric field was constant in time. As an extension, the new model includes several types of variations of the external electric field responsible for ion creation. The following phenomena are taken into account: ion creation of both polarities (bipolar medium), capture of small ions by neutral aerosol particles as well as by other ions of opposite polarity, influence of turbulent diffusion. The model provides the transient response of the space charge to two types of variation of the electric field created by a thundercloud: the rapid variation due to a lightning stroke and the slow recovery which occurs during regeneration. Time and space evolution of the various parameters are deduced from the computation: small and large ion concentrations, space charge density, current density and electric field. The different results reveal the tremendous influence of the space charge on the electric field variation at ground level, especially after a lightning stroke. Values of corona current density higher than 20 nA m^{-2} following 20 kV/m field steps can create such a high ion concentration that the surface electric field can be rapidly reduced to a value close to the corona threshold regardless to the intensity aloft. Electric field profiles plotted after a lightning stroke often show opposite polarities of the electric field at ground level and aloft. (electric field, ions, aerosol, point discharge, corona, thunderstorms).

J. Geophys. Res., D, Paper 4D1361

3799 General (Ion Production)
ENHANCED ION PRODUCTION IN CONVECTIVE STORMS BY TRANSPIRED RADON ISOTOPES AND THEIR DECAY PRODUCTS
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Transpired radon and thoron and their radioactive decay products give rise to surprisingly high concentrations of radioisotopes and ions in surface air which feeds the core of updrafts in convective storms. Published evidence and other considerations in support of this new hypothesis are reviewed and discussed. Effective transpiration of radon isotopes is due to their high concentration in soil gas and high solubility in water. Meteorological and other factors which influence plant transpiration and their diurnal and seasonal variations are discussed. It is concluded that radioisotopes of continental surface origin give rise to enhanced rates of ion production in convective storms which exceed that of cosmic rays at an altitude of 5 km by factors of 5 to 10 or more. (Radon, ion production, thunderstorms).

J. Geophys. Res., D, Paper 4D1365

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